REFINER
AND NATURAL GASOLINE MANUFACTURER

MAY, 1935
Vol. 14, No. 5

A Gulf Publishing Company Publication
EDITED MONTHLY AT HOUSTON, TEXAS

Copyright, 1935

GEORGE REID
Editor

CONTENTS

Special Features

Vacuum Refrigeration System 199
F. L. Kallam

Method of Determining Efficiency of Fractionating Towers 202
T. L. McNamara

Some Factors in Engine Knock 208
A. W. Trusty

Inspection of Refinery Equipment—Part 3 211
Franklin L. Newcomb

Changes in Lubricating Oils During Use 219
Hans Muller and Werner Muller

Alloyed Cast Iron in Petroleum Refining Equipment—Part 2 .. 221
J. S. Vanick

Design of Fractionating Columns—Article 2, Part 2 227
G. G. Brown, Mott Souders, H. V. Nyland and Wm. W. Hesler

Physical and Thermodynamic Properties of Methane and Ethane 232
I. N. Beall

Correlating Comparison of Chart Interpretations 235
F. B. Taylor, Jr.

Regular Departments

The Look Box ..... 197 and 33a

Plant Activities 39a

Science and Technology (Abstracts) 42a

New Equipment for the Modern Plant 53a

Catalogs and Bulletins 57a

Advertisers' Index 58a

SPECIALIZED OIL JOURNALS

Published by

GULF PUBLISHING COMPANY

OFFICE OF PUBLICATION
3301 Buffalo Drive, Houston, Texas

R. L. DUDLEY, *President*
A. L. BURNS, *Gen'l Manager*
S. W. ROBINSON, *Editorial Director*
J. KENT RIDLEY, *Managing Editor*

NEW YORK: Room 1023, 250 Park Avenue, Dick Swinsky, Manager.

PITTSBURGH: 902 Standard Life Building, W. W. Pigue, Manager.

CHICAGO: Room 1834, 332 So. Michigan Ave. T. W. Nelson, Manager.

LOS ANGELES: 416 Haas Building, W. E. Green, Manager.

TULSA: 1020 Hunt Building, J. F. Carter, Jr., Manager.

FORT WORTH: 203 W. T. Waggoner Building, H. H. King, Manager.

Single copies 20 cents. Domestic and Foreign subscription price, $1.00 a year. Entered as second class matter June 16, 1923, at the post office at Houston, Texas, under Act of March 3, 1879. Advertising rates on application.

The answer to your **cooling** problem may be VACUUM

ELLIOTT VACUUM EQUIPMENT for Air Conditioning and Process Cooling

Is it process work? Is it air conditioning? Then it is a VACUUM COOLING job.

Get the inside facts about this low-cost, modern method of cooling—the new booklet, illustrated below, will give them. Then check on your particular proposition with an Elliott engineer, who will be able to tell you in short order, exactly what equipment you will need, and how much you will save by VACUUM COOLING.

Remember—Vacuum Cooling means *no chemicals, minimum maintenance, practically no moving parts, no bulky equipment.*

Investigate—write us today.

G-334

Steam Jet
VACUUM COOLING EQUIPMENT
Water inlets to flash chamber compartments (water at 56° F.).
Steam inlets to boosters. Boosters can be designed for any steam pressure above atmospheric pressure.
FLASH CHAMBER
Four separate compartments, 200 g.p.m. of 56° F. water sprayed into each compartment and cooled to 50° F.
BOOSTER EJECTORS
For flexibility and efficiency at part loads, four 50-ton ejectors used. At full load, they compress 2260 lbs. per hr. of flashed vapor, from 29.64" to 28.34" vacuum.
BOOSTER CONDENSER
Two-pass surface type. Maintains 28.34" vacuum, with 80° F. condensing water.
Chilled water pump (800 g.p.m.).
Chilled water manifold from flash chamber compartments (water at 50° F.).
WRITE FOR THIS NEW BULLETIN —TO-DAY

ELLIOTT COMPANY

PITTSBURGH, PA.

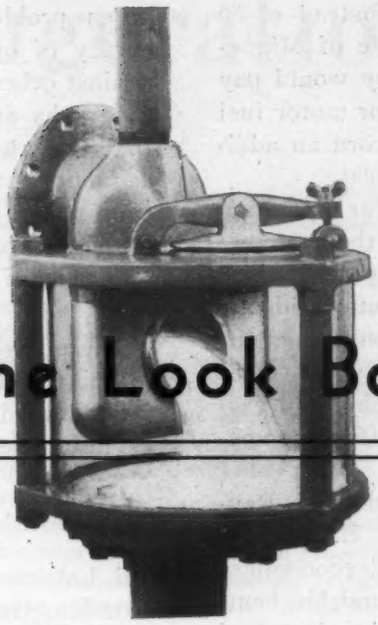
Heat Transfer Department
JEANNETTE, PA.
District Offices in Principal Cities

PIONEERS IN THE DESIGN, CONSTRUCTION AND APPLICATION OF STEAM JET EJECTORS

VOLUME 14, No. 5 MAY, 1935

REFINER
AND NATURAL GASOLINE MANUFACTURER

A Gulf Publishing Company Publication



The Look Box

GASOLINE consumption in the United States in 1934, totalling 16,595,180,000 gallons, was the second largest in history, according to consumption figures made public by the American Petroleum Institute's Department of Statistics. Total consumption in 1934 has been exceeded only by that of 1931, when the total reached 16,628,880,000 gallons.

Consumption Increased

The department's report was compiled from official data of the various states indicating the number of gallons upon which state gasoline taxes were collected, or which were exempted from taxation. The total, consequently, includes gasoline used for all purposes, rather than merely in motor vehicles.

New York retained its place as the largest gasoline-consuming state, 1934 consumption being 1,577,019,000. Second largest consumption was reported by California, 1,334,177,000 gallons, and Pennsylvania was in third place with 1,136,344,000.

The total consumption for 1934 showed a gain of more than one billion gallons over 1933, consumption that year being 15,436,324,000 gallons. Consumption in 1932 was 15,497,158,000.

Gasoline consumption is dependent upon so many variable factors that it is impossible to ascribe the increase to any one cause. They include business conditions, motor vehicle registration, and the weather, and the increase in 1934 consumption probably may be ascribed to all these, plus widespread efforts to enforce gasoline tax laws and to prevent tax evasion. For instance, Texas has been making strenuous efforts to enforce these statutes and to collect gasoline taxes in full. The state's 1934 consumption is more than 100,000,000 gallons above that of 1933. Similarly, a 55,000,000-gallon increase is shown in Illinois, where efforts to prevent tax evasion also have been extensive.

Based upon this indicated consumption and an average retail price of 13.64 cents per gallon for gasoline in 1934, it is estimated that the American public paid roundly $2,263,582,552 for its motor fuel last year. In addition the public was taxed an average of 5.2 cents per gallon for a total of $862,949,360, or nearly 40 percent of the retail price of gasoline. Exemptions and refunds, however, reduced this tax cost by about $100,000,000.

A STUDY of the proposed plan for compelling American motorists to use alcohol-blend fuels, made by University of Minnesota research experts, has led to their conclusion that it is an impractical political expedient based on false economics, according to information reaching the American Petroleum Industries Committee.

Alky-Gas

Denying the statements of proponents that

the plan, not being considered as national and state legislation, would benefit the farmers by creating a market for alcohol made from corn, the report said that quite the opposite would be true. It would increase gasoline prices to the injury of the farmers and other consumers, indications being that 10 gallons of motor fuel would cost 78 cents at refineries instead of 50 cents, the current price. In the case of Minnesota farmers, it was found that they would pay an estimated $4,160,000 additional for motor fuel each year, but would obtain from corn an additional income of only about $2,000,000.

Increased difficulties of motor car operation also were reported, it being said that the vehicles would not operate efficiently and, since the burning of alcohol produces acetic acid, the motors would be subject to corrosion. Other difficulties would result, particularly in cold weather, from separation of the alcohol and gasoline, making starting ordinarily difficult, sometimes impossible.

Those making the survey included L. H. Reyerson, professor of chemistry; O. B. Jesness, chief of the division of agricultural economics; R. H. Gortner, chief of the agricultural biochemistry department; and R. S. Vaile, professor of marketing. The survey was made at the request of Dr. Lotus D. Coffman, president of the University of Minnesota, and Dean W. C. Coffey, of the College of Agriculture.

Inspection

"Inspection of Refinery Equipment" Part 3 appears in this issue. In this series of articles by F. L. Newcomb, supervising engineer in charge of Safety Inspection Division, General Engineering Department, Standard Oil Development Company, has been attracting considerable interest and aroused much favorable comment. So much so in fact, that plans are tentatively arranged for republication of the series of five articles in book form for general distribution at a nominal cost.

Mr. Newcomb's series is comprehensive in its scope and but little of value to those interested in the purchase, operation, maintenance, and ultimate disposal of refinery equipment has been omitted.

Pick up the series with Part 3 in this issue and follow it to its conclusion. Later, reprints of the full, authoritative work will be available and in bound form. In the current issue, wall thickness, hammer tests, hydraulic tests, inspection of furnaces and fire boxes, testing of safety valves, fire protection facilities, general safety features and the tools required are discussed.

Page 211.

Methods

Usually there are a number of means of determining the answer to a given problem. The determination of the efficiency of fractionating columns is no exception, and T. L. McNamara presents five methods for such determinations. After presenting the methods he applies them to a given problem and further, compares the accuracy of one method against another, or one against others, and through the use of a number of graphs and charts arrives at the conclusion that the true picture of the actual workings of a fractionating column is not best obtained by a comparison of the true boiling point still work-up of the charge itself but by a similar work-up of a blend of the products.

Page 202.

Sludges

There has been a lot of discussion among the technically inclined and others not at all technical in regard to just what this stuff is that forms as impurities in the lubricating oil and is so blackly visible upon draining the crank case. Hans Muller and Werner Muller of the staff of the Chemical Laboratory of the Technical High School, Dresden, Germany, wanted to know the same answers so they investigated the changes in lubricating oils during use and the resulting products. Their results are presented in a translation.

Page 219.

Alloys

ALLOYED cast irons find application in the refining industry in such equipment as furnace parts, compressor heads, pistons, cylinders, corrosion resistant materials such as condenser tubes, bubble trays and caps, also pumps handling various slurries, and others. In the second and concluding part of his article "Alloyed Cast Irons in Petroleum Refining Equipment," J. S. Vanick discusses in detail the corrosion resistance, physical properties, and specifications of a number of different alloyed cast irons for and discusses their application to various items of equipment.

Page 221.

Cooling

NO industry profits more from low cooling water temperatures than that of oil refining and natural gasoline manufacture and for this reason the steam jet vacuum refrigeration system should be of interest to this industry. Its principles and application are discussed by F. L. Kallam in this issue of THE REFINER. He states that the cost of operation compares favorably with other systems within its proper operating range.

(*Continued on page* 33a)

Vacuum Refrigeration System

F. L. KALLAM
Industrial Engineers, Inc., Los Angeles

AIR conditioning has opened up a field of steadily increasing importance. One installation of the past year was the new Field Building in Chicago, involving a 600-ton refrigerating unit. Probably the most spectacular installation was that at Rockefeller Center in New York City. The total refrigeration in this group of seven buildings is 4450-tons, 600 of which are produced by the steam-jet system. The Chicago Tribune installation of another 600-ton vacuum refrigeration unit showed how this type of equipment could be advantageously used in an existing office building.

The vacuum system has a large potential field in industrial refrigeration, the 600-ton steam-jet installation at the Anheuser Busch Brewery being an excellent example. There, 720-g.p.m. of 85°F. water is cooled to 65°F. Another unit, with a rating of 75-tons of refrigeration, is maintaining a cooled water temperature of 45°F. in one of the country's largest silk dyeing establishments.

As has previously been pointed out,[1 2 3] no industry profits more from low cooling water temperatures than that of oil refining and natural gasoline manufacture. For this reason, the "re-discovered" method of steam-jet refrigeration should be of interest to those connected with these two industries.

STEAM-JET refrigeration is not, as is often supposed, a new development. Only recently has it been given any great attention, although commercial units were in operation nearly 17 years ago. Many conditions have come about during the last decade that have favorably affected these units. Among these are improvements in boiler efficiencies, with attendant reduction in steam costs, and improvements in steam-jet compressors resulting in greatly reduced steam consumption. Then, too, the development of highly efficient steam-actuated air ejectors to replace hydraulic and rotative dry-vacuum pumps permitted a decrease in first cost of the units as well as lower operating charges. A further aid to the steam-jet refrigeration unit has been the remarkable improvement in steam condenser performance and efficiency which has materially decreased the water required for cooling.

Vacuum refrigeration may be compared to the cycle in the conventional water cooling tower. In both systems the liquid to be cooled efficiently must be finely divided for rapid evaporation. In the cooling tower, evaporation takes place at a relatively high temperature but always at atmospheric pressure. In the case of the steam-jet unit, however, the water must be evaporated at low temperature and consequently at low absolute pressure. This calls for the boiling or evaporation to take place under a high vacuum.

For example, take the case of where 80°F. water is to be chilled to a temperature of 40°F. To make this reduction in temperature, heat must be removed from the water. This can be brought about by evaporating a portion of the water, without the application of external heat, since in so doing, the necessary heat will be extracted from the water itself. By subjecting the 80°F. water to the pressure at which it will boil at a temperature of 40°F., a portion will be converted into vapor. In this way, the heat of vaporization is removed from the main body of the water, causing a reduction in its temperature.

To cool the water through the specified range of 40°F. requires the removal of approximately 40 B.t.u. per pound of water. On the other hand, however, it takes about 1000 B.t.u. to convert one pound of water into vapor or steam. Thus to cool the pound of water from a temperature of 80 to 40°F., it is necessary to evaporate only 0.04 pounds of water. From this it is plain that an extremely small percentage of liquid need be evaporated to accomplish a very considerable amount of cooling.

A glance at the steam table indicates the vacuums or reduced pressures that must be produced within the evaporating chamber to cool water to the listed temperatures:

Water Temperatures °F.	Vacuum Referred to a 30" Barometer Inches Hg.
60	29.48
55	29.56
50	29.64
45	29.70
40	29.75
35	29.81

To maintain these reduced pressures it is obviously necessary that the vapors resulting from the evaporation be removed at whatever rate they are produced by some form of pump or compressor. As would be expected at such low pressures, the vol-

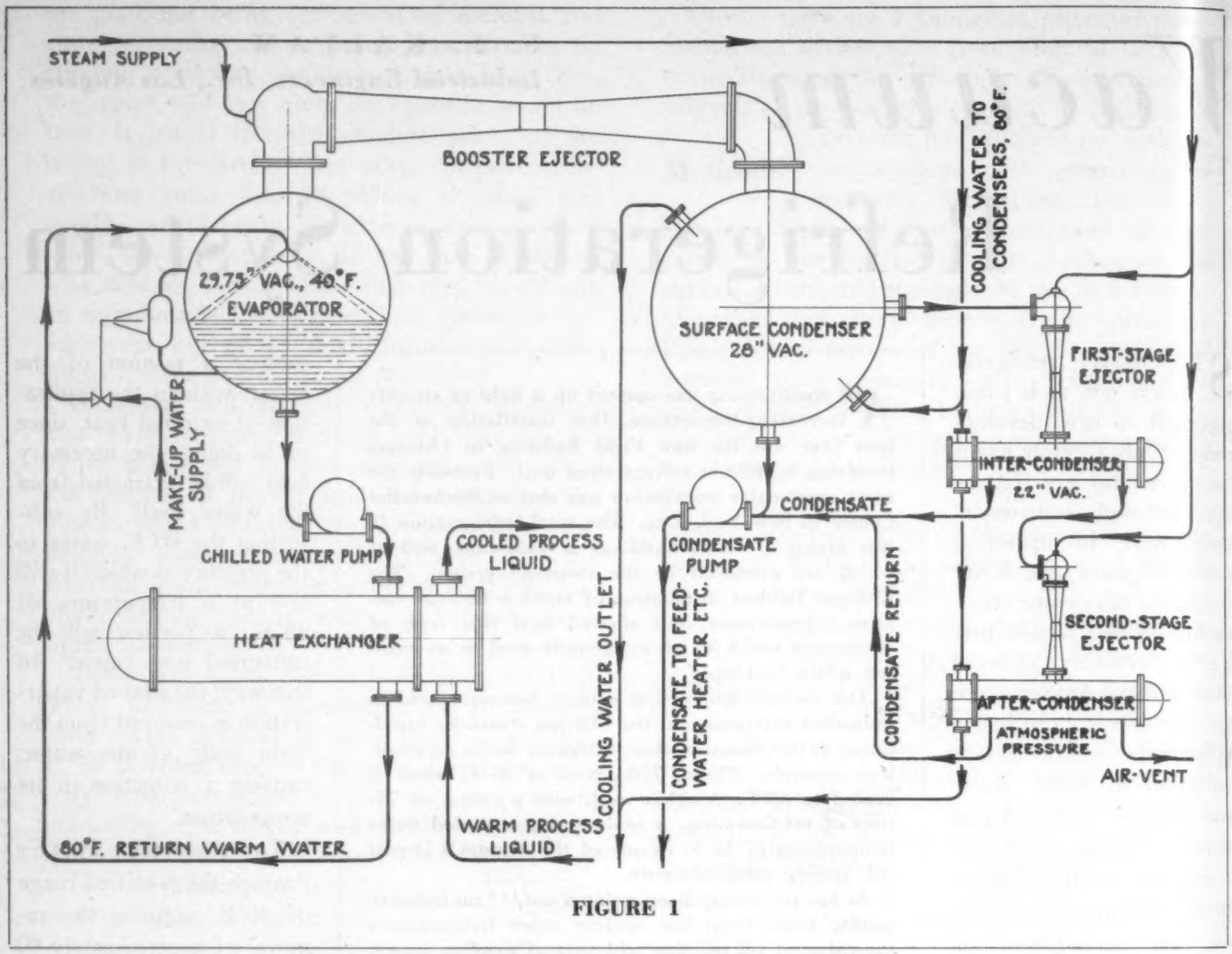


FIGURE 1

umes to be displaced are necessarily large. For example, one pound of water vapor at 40°F. has a volume of 2445 cubic feet, as compared with 26.8 cubic feet at 212°F. Hence for each ton of refrigerating capacity (removal of 200 B.t.u. per minute) 489 cubic feet of vapor per minute must be removed. It will be apparent that, with such a unit volume of vapor to be removed any displacement type of vapor pump would be unduly large and not economical for this reason alone.

Recent refinements of the steam jet thermo-compressor have fortunately supplied a device which has a very large volumetric capacity and therefore is adaptable for removing the vapors in vacuum refrigeration systems. This apparatus, which is the heart of the system, consists essentially of a steam nozzle or a group of steam nozzles directed toward a compression throat and provided with an opening for the admission of the vapors to be compressed. Steam issues from the nozzles at velocities of 3500 to 5000 feet a second, draws in the cold vapors by aspiration and compresses the entire mass within the throat and diffusor to some higher pressure than that existing within the flash chamber.

Although it would be physically possible to compress the combined vapors all the way to atmospheric pressure, the lower the ratio of compression the smaller will be the amount of steam necessary to do the compression work. It is therefore customary to design the thermo-compressor for vacuum refrigeration service so as to increase the pressure of the vapors only to such a point that they may be condensed. These vapors would have a condensing temperature slightly higher than that of the available water supply. Condensation is therefore made possible within an ordinary steam condenser at pressures around 28 inches vacuum. This leaves only the non-condensible vapors resulting from air leakage or solution to be compressed to atmospheric pressure. The conventional auxiliary steam jet air pump is suitable for this service.

The flow diagram shows a typical application of the vacuum refrigeration system. Water is to be cooled from 80 to 40°F. as in the previous example. The water to be cooled enters the evaporator, or flash chamber, through a system of sprays which breaks it up into a fine mist. A vacuum of 29.75 inches (referred to a 30-inch Barometer) is maintained in the evaporator, causing a small amount of the water to flash into steam. The amount so flashed is only four percent of the total water, yet in absorbing its heat of vaporization from the remaining 96

percent, the main body of water is chilled to the required 40°F. This chilled water is withdrawn from the bottom of the evaporator and pumped to the point where it is to be used. The evaporation loss is replaced by make-up water supplied from an outside source or by the return of condensate from the main condenser.

The necessary vacuum is maintained in the evaporator by the thermo-compressor or booster ejector and air ejectors. Compression of the steam which has been flashed, plus the air which has entered the system with the water, is brought about by the jet booster from a vacuum of 29.75 to 28 inches. For this work either high or low pressure steam may be used as the compressing or propelling medium.

In the main condenser, the steam from the evaporator and the propelling steam from the booster is condensed, while the air is further compressed from 28 to 22 inches Hg. and then to atmospheric pressure by the secondary ejectors. The inter- and after-condenser condenses the propelling steam of the secondary ejectors. A condensate pump removes the condensed steam, discharging it to a sump or into the make-up line for the cooling tower, boiler feed, or refrigerating circuit. Although the closed surface type of condensers are shown in the flow diagram, where conditions make it advisable, the barometric type may be substituted with no change in the results obtained.

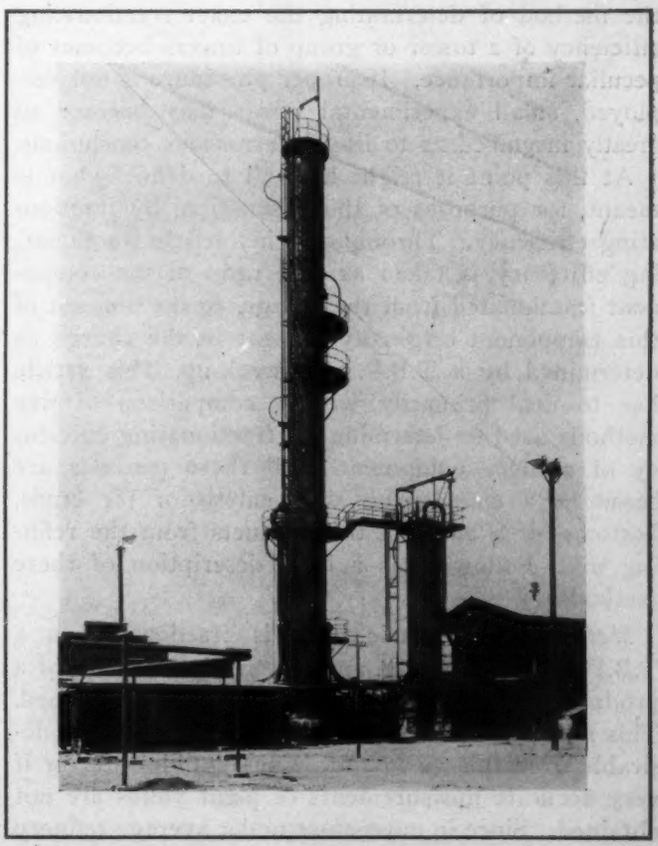
Vacuum refrigerating units will produce chilled water having a temperature of 32°F. or above. Where very cold water is necessary, as below 40°F., the pressure to be maintained in the evaporator must closely approach a perfect vacuum, and the steam and water requirements are correspondingly high. For temperatures, as between 40 and 60°F., only a moderate vacuum is required and the consumption of steam and water decrease rapidly. It is within this range that the economics of the vacuum refrigeration system are most apparent. Units designed for temperatures below 40°F. are, however, entirely satisfactory and compare favorably in operating costs with conventional mechanical systems.

A vacuum unit designed to produce 65 tons of refrigeration with a chilled water temperature of 40°F. requires a definite steam and water rate. If the chilled water temperature be lowered to 32.5°F., at the same time keeping these same steam and water rates, the refrigeration tonnage of the unit will decrease to 25 tons. On the other hand, if the chilled water temperature be raised to 60°F., the machine will produce 130 tons of refrigeration. It is apparent that the most economical steam jet plant will be obtained when using the highest chilled water temperature compatible with the service requirements.

The operation of a vacuum refrigeration unit is automatic and requires little or no attention. A float control operating on the warm water inlet to the evaporator maintains a constant level of chilled water in the flash chamber.

A thermostatic control valve operating on the main steam line closes-off the steam to the ejectors when the chilled water temperature goes below any desired temperature. Or it may be utilized only as a safety device to prevent freezing of the refrigerant in the evaporator. Controls can also be arranged whereby a decrease or increase in tonnage can be effected by automatically regulating the number of jet-boosters in service.

As compared with other forms of refrigeration it is to be noted that in the vacuum system the cooled water is refrigerated directly without the necessity of an intermediate medium such as ammonia or carbon dioxide. Cost and difficulties of handling such media is thereby eliminated. The steam-jet unit operates under a vacuum and is therefore not subject to the danger of explosions. No noxious or poisonous vapors can escape from the vacuum system. Further, there are no moving parts except the rotors of two centrifugal pumps, and the unit as a result operates noislessly and free from vibration. Lubrication problems are consequently unknown. The cost of operation of the vacuum jet system therefore compares favorably with other systems within its proper operating range.



[1]Cooling Problems in Refineries and Natural Gasoline Plants. W. L. Rifenberick and F. L. Kallam, National Petroleum News, October 17, 1928.

[2]Refrigeration in the Gasoline Industry: F. L. Kallam, Proceedings of the California Natural Gasoline Association, January, 1931.

[3]Application of Refrigeration to the Manufacture of Natural Gasoline: F. L. Kallam, Chemical & Metallurgical Engineering, July, 1934, Volumn 41, No. 7.

Methods of Determining

Efficiency of Fractionating Towers . . .

T. L. McNAMARA
Chief Chemist, Root Refining Company

VARIOUS methods have been proposed and are used in determining the degree of fractionation or separation by distillation obtained on petroleum fractionating towers. Some methods call for an Engler distillation of the bottoms, others on a gap between the initial boiling point of the bottoms and the end point of the overhead, while others are based on the old-fashioned Hempel distillation. However, the most reliable methods for determining the efficiency of separation, hereinafter called the fractionating efficiency, is based on a comparison of the results obtained by distillation in an experimental laboratory still capable of effecting a high degree of separation. These experimental stills have become designated as true boiling point (T.B.P.) stills because they approach as closely as possible the separation by fractionation of the components of a mixture charged into it. Also, the overhead vapor temperature approaches as closely as possible the true boiling point of the fraction distilling over.

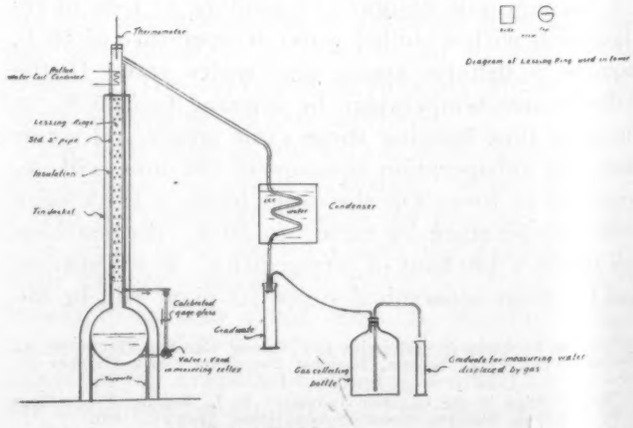
In determining the effect of reflux ratio, number of plates, plate spacing, number and kind of bubble caps, or other variations on a fractionating tower, the method of determining the exact fractionating efficiency of a tower or group of towers becomes of peculiar importance. If proper procedure is not employed, small experimental errors may become so greatly magnified as to lead to erroneous conclusions.

At this point it might be well to define what is meant, for purposes of this discussion, by fractionating efficiency. Throughout this article fractionating efficiency is taken as that ratio of the component fractionated from the charge, to the amount of this component originally present in the charge as determined by a T.B.P. still work-up. This article has to deal primarily with a comparison of five methods used to determine the fractionating efficiency of refinery equipment. All these methods are based on a true boiling still analysis of the crude, bottoms, or a blend of the products from the refining unit. Following is a brief description of these methods:

Method 1. The crude itself is fractionated on a T.B.P. still (Figure 1), and the maximum yield of a product of any specified end point is determined. This method, while the most direct and therefore desirable from this viewpoint, is susceptible to error if very accurate measurements of plant yields are not obtained. Since in most cases under average refinery conditions the yields are not obtained with the high accuracy necessary, this method cannot, in general, be expected to give accurate results.

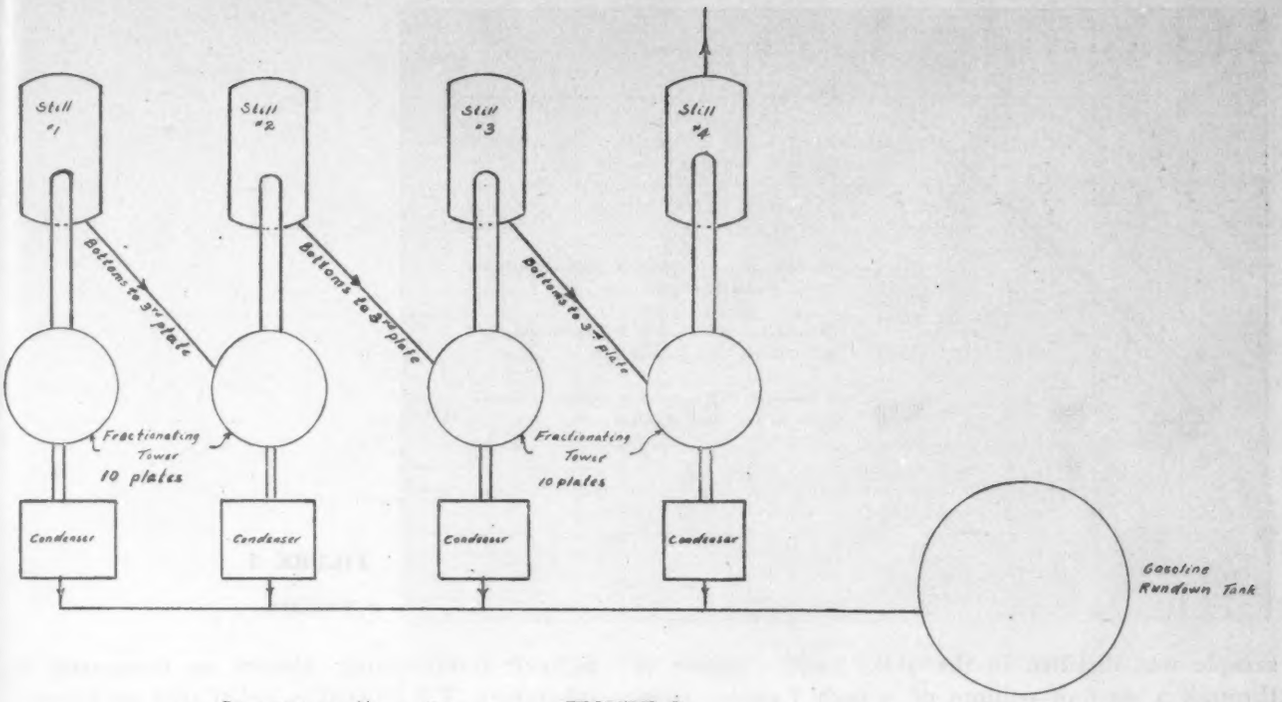
Method 2. In this method the products from the refinery fractionating equipment, overhead and bottoms, are blended together in the same proportion as the reported yields, thus forming a synthetic crude which is then redistilled in the T.B.P. still. The fractionating efficiency would then be the ratio of the amount of overhead placed in this blend to the amount of this overhead (having the same end point) obtained from the T.B.P. still. In this method reasonable errors in the reported plant yields would not effect the accuracy of the final answer, for here known amounts of the actual products from plant equipment are blended together and compared with the maximum amounts possible to be obtained. This method is probably the most accurate of any yet devised.

Method 3. In this method a sample of the bottoms is distilled in a T.B.P. still and material having the same end point as the plant product is taken off. This is the actual amount of the product which has



TRUE BOILING POINT STILL

FIGURE 1



BATTERY HOOK UP **FIGURE 2**

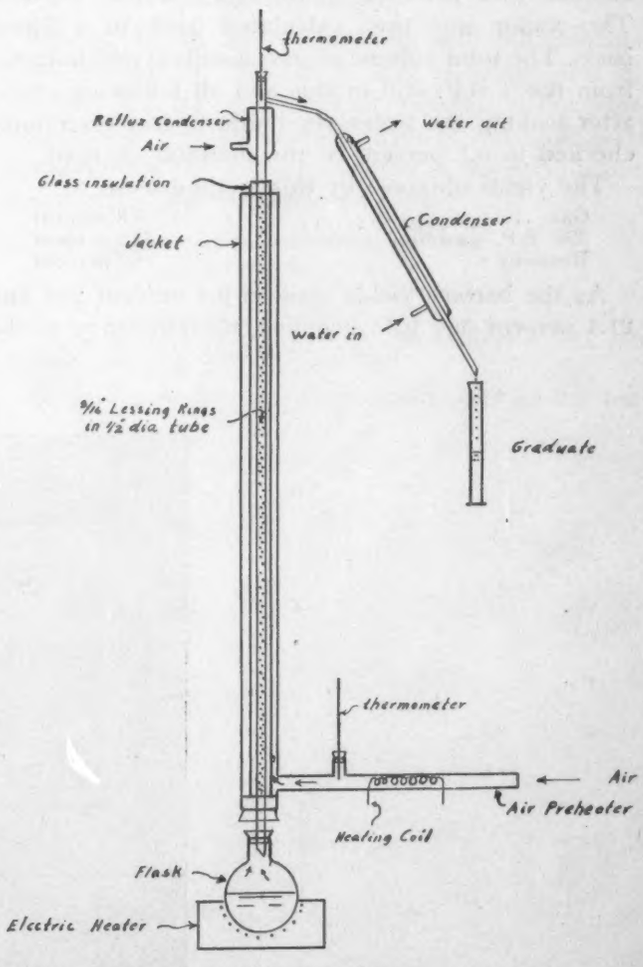
not been removed from the bottoms by the plant equipment. The fractionating efficiency in this case would be the ratio of the amount obtained from the plant unit to the sum of this amount and the amount left in the bottoms.

Method 4. This is simply a modification of the preceding method. Instead of determining the end point of the overhead from the T.B.P. still alone, it is blended in yield proportion with the refinery overhead until the end point of the latter is raised.

Method 5. In this method a glass apparatus (Fig. ure 3) requiring much smaller quantities of charge is used. The procedure is similar to Method 3 in that the bottoms of the plant unit are charged into this apparatus and the light material distilled off. As the quantities of overhead obtained are too small to obtain an Engler distillation, the vapor temperature is assumed to be the same as the end point. The amount over at the temperature corresponding to the endpoint of the refinery product is taken as the amount of this product in the bottoms. The fractionating efficiency is then calculated as in Method 3.

A 24-hour test run was made on a battery of shell stills (Figure 2) with all the gasoline streams running into the same tank. Hourly samples of the crude and the split still bottoms were taken and composited. The overall fractionating efficiency with gasoline of 390°F. end point as the component to be removed was determined by each of the five methods. Careful measurements were made of the battery yields of gas, overhead and bottoms. The plant yields showed 21.4 percent 390 EP gasoline, 0.4 percent gas and 78.2 percent bottoms.

Method 1. Five gallons of the composite crude



GLASS TRUE BOILING POINT STILL

FIGURE 3

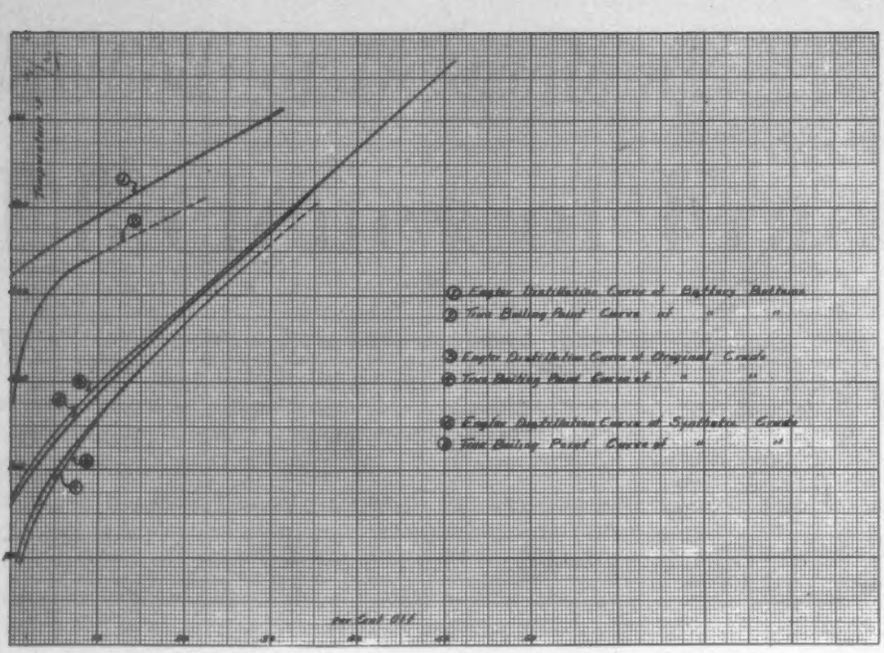


FIGURE 4

sample was distilled in the T.B.P. still (Figure 1) through a six-foot column of ¼-inch Lessing rings using a reflux ratio of approximately 10:1. The gas evolved in the distillation was trapped in five-gallon bottles by water displacement and analyzed for the amount and kind of hydrocarbon vapor present. This vapor was then calculated back to a liquid basis. The total volume of gas, distillate and bottoms from the T.B.P. still in this and all following cases, after making the necessary temperature corrections, checked to 0.1 percent of the material charged.

The yields obtained by this method were:

Gas	0.8 percent
390 E.P. gasoline	23.5 percent
Bottoms	75.7 percent

As the battery yields showed 0.4 percent gas and 21.4 percent 390 E.P. gasoline, the efficiency of the battery fractionating towers as compared to the laboratory T.B.P. still is calculated as follows:

$$\text{Efficiency} = \frac{0.4 + 21.4}{0.8 + 23.5} \times 100 = 89.7 \text{ percent}$$

Method 2. Five gallons of a synthetic crude were made by blending together the gasoline obtained from the battery and the bottoms from the split still in the ratio of these yields.

Thus the percent of gasoline in this synthetic crude would be:

$$\frac{21.4}{21.4 + 78.2} \times 100 = 21.5 \text{ percent}$$

and the percent of split bottom 78.5 percent.

This blend was distilled in the T.B.P. still using the same procedure as in Method 1, with the gas

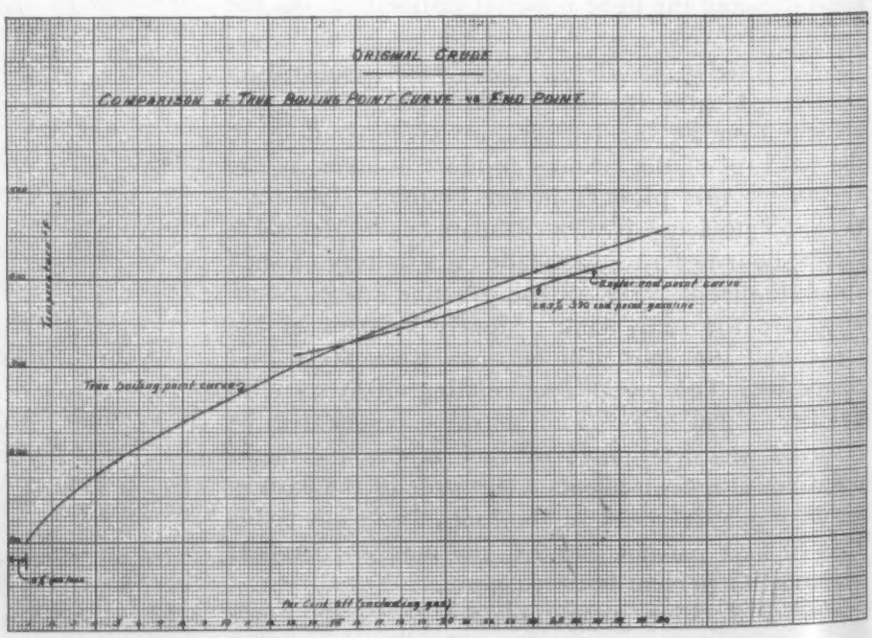

ORIGINAL CRUDE
COMPARISON OF TRUE BOILING POINT CURVE VS END POINT
Temperature F.
Engler end point curve
True boiling point curve
Per Cent off (excluding gas)

FIGURE 5

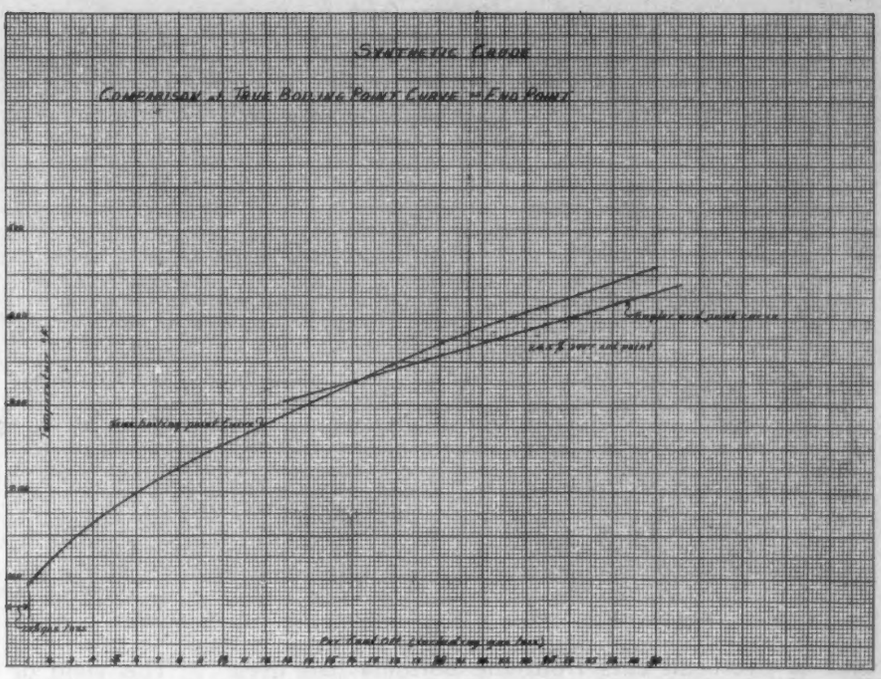


FIGURE 6

evolved being measured, analyzed, and calculated back to liquid volume.

Following are the yields obtained:

Gas ..... 1.0 percent
390 E.P. gasoline ..... 23.5 percent
Bottoms ..... 75.5 percent

The efficiency of the battery fractionating towers is calculated as follows:

$$\text{Efficiency} = \frac{21.5}{1.0 + 23.5} \times 100 = 87.8 \text{ percent}$$

Method 3. Five gallons of split bottoms representing 78.2 percent of the crude charged to the battery was distilled in the T.B.P. still using the same procedure as before.

Following are the yields obtained:

Gas ..... 0.4 percent
390 E.P. gasoline ..... 3.5 percent

The efficiency of the battery towers is calculated as follows:

$$\text{Efficiency} = \frac{21.4 + 0.4}{21.4 + .4 + .782\ (3.5 + .4)} \times 100 = 87.7 \text{ percent}$$

Method 4. In this method the split still bottoms were charged to the T.B.P. still as above, but instead of running an Engler distillation on the overhead alone, the one percent cuts taken off were blended with the battery naphtha in the ratio as determined by the following formula:

Percent of any one percent cut in blend:

$$\frac{.782}{21.4 + .782N} \times 100$$

Where N is the number of the one percent T.B.P. cuts blended with the battery naphtha.

In this case the end point was raised as 2.5 per-

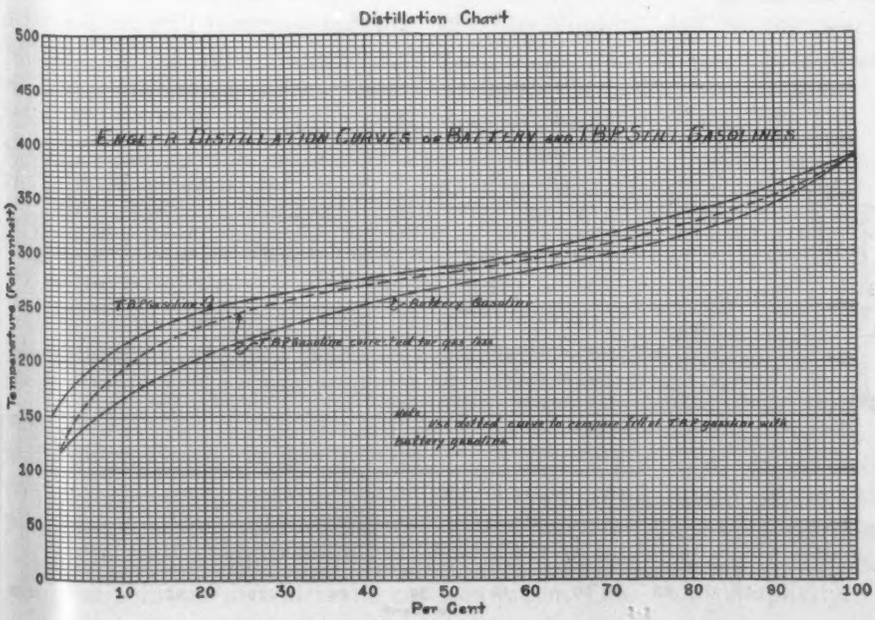


FIGURE 7

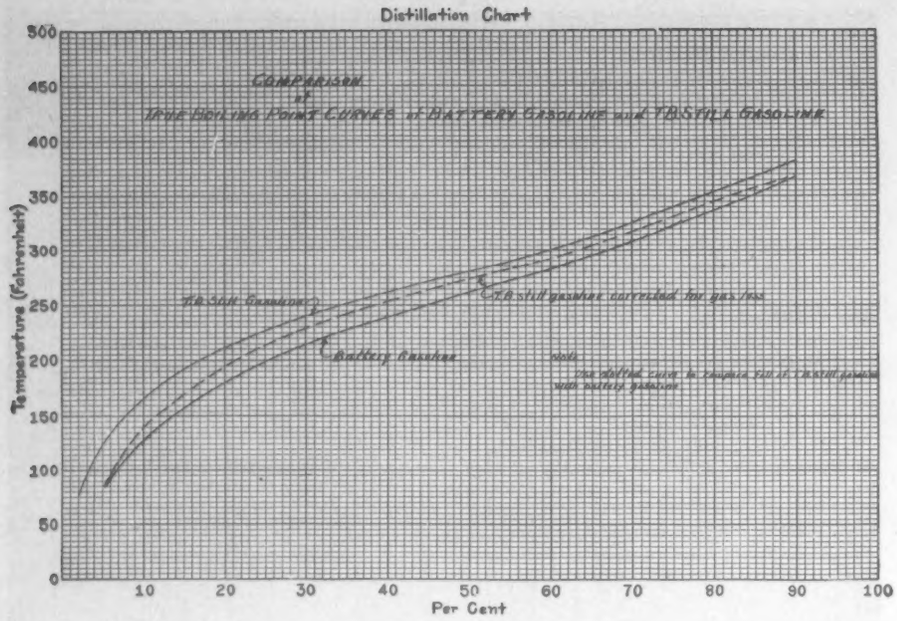


FIGURE 8

cent of overhead cuts from the bottoms had been added.

The efficiency is calculated as follows:

$$\text{Efficiency} = \frac{21.4 + .4}{21.4+.4+.782\ (2.5+.4)} \times 100 = 90.6 \text{ percent}$$

Method 5. In determining fractionation efficiencies by Method 3 it had been noted in this and previous cases that the vapor temperature at the top of the column on the T.B.P. still corresponded very closely with the end point of the overhead fraction. It seemed, therefore, that a smaller apparatus might be used if the necessity of running an Engler distillation on the overhead could be removed, thus avoiding the more tedious and cumbersome methods outlined above.

Accordingly a glass apparatus shown in Figure 3 was constructed and 300 c.c. of the split still bottoms distilled through the four-foot length of column packed with 3/16-inch Lessing rings at a distillation rate of three to four cubic centimeters per minute, while maintaining as much reflux as possible without flooding the column.

The yield of overhead obtained at a vapor temperature of 390°F. was 3.6 percent of the charge.

The calculated efficiency:

$$\frac{21.4 + .4}{21.4 + .4 + .782 + 3.6} \times 100 = 88.5 \text{ percent}$$

The following table briefly summarizes the results of these experiments:

METHOD	Gas	Yields 390 E. P. Gaso.	Total Yields Gas and Gasoline	Calculated Fractionating Efficiency
1. Crude.....	0.8	23.5	24.3	89.7
2. Synthetic Crude.	1.0	23.5	24.5	87.8
3. Bottoms.....	0.4	3.5	3.9	87.7
4. Bottoms.....	0.4	2.5	2.9	90.5
5. Glass Apparatus.	...	3.6	3.6	88.5
Plant Yields.....	0.4	21.4	21.8	....

The fractionating efficiencies as determined by these various methods, while not showing any ex-

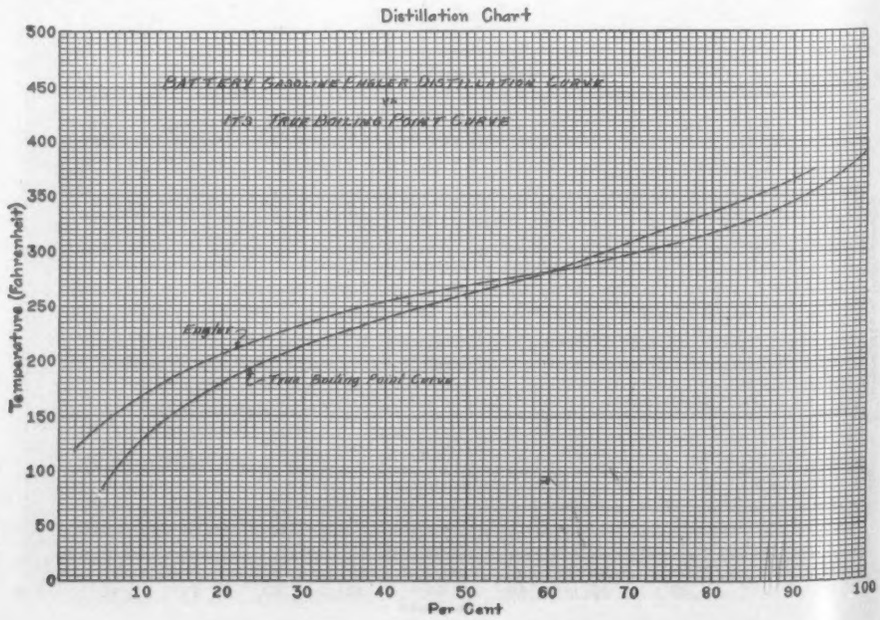


FIGURE 9

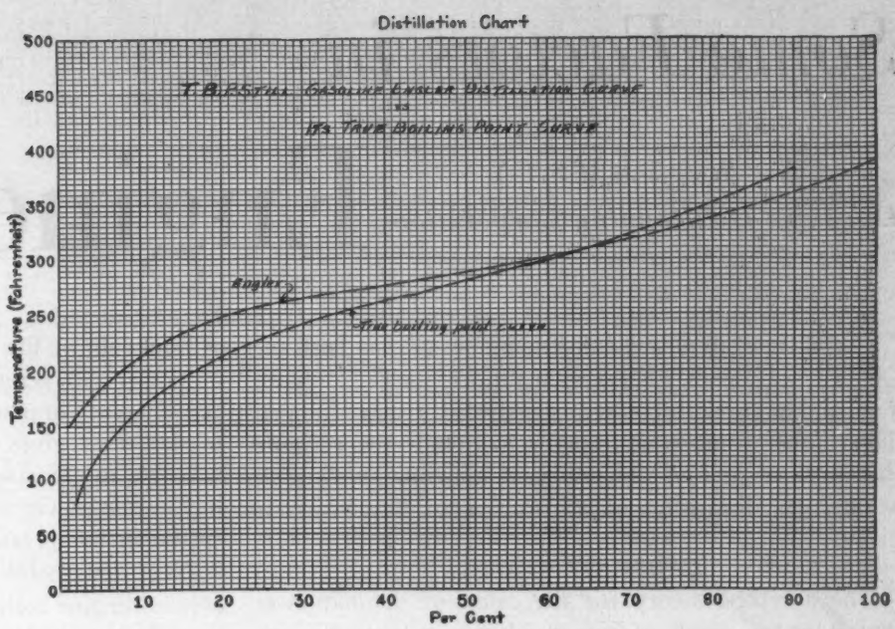


FIGURE 10

treme differences do indicate the unreliability of Methods 1 and 4. The latter would be expected to give higher ratings than the others due to the manner in which it is derived. Theoretically Method 1 should check exactly with Method 2. Its failure to do so is probably due in part to inaccuracies in the reported yields and in part to weathering of the crude previous to testing. That one or the other or both of these factors are responsible is plainly indicated by a comparison of the distillation curves of the original and the synthetic crudes which show the latter to contain more volatile fractions. Experience has proven that Method 2 offers a better picture of the actual working conditions of a fractionating column than any of the other methods. Since Method 5 checks very closely with this method its use is preferred due to its simplicity and brevity.

Figure 4 shows a plot of the true boiling point curves of the original crude, the synthetic crude, and the split still bottoms, together with the Engler distillations. An interesting observation is that in the case of the split still bottoms, the Engler distillation showed an initial boiling point of 420°F. Since the end point of the battery gasoline was 390°F., this gives a gap of 30°F. between battery gasoline and the initial boiling point of the bottoms. In spite of this high initial, there was 3.5 percent of 390°F. end point material in these bottoms.

The graphs in Figures 5 and 6 show a comparison between the end point of the overhead fraction and the true boiling point curves of the crudes. An interesting observation is that end points of the overhead in the neighborhood of 325°F. check the vapor temperature at which the cut was taken. Lower end points have higher values than the vapor temperature, while above 325°F. the end point is below the vapor temperature at which the cut was taken. This fact may be explained by two factors: first, the carrying effect of the lighter ends becomes more effective as the end point is increased tending to decrease it; second, at lower end points the superheating error in the Engler distillation becomes more noticeable.

Figure 7 shows a comparison between the Engler distillation curves of the battery gasoline and the gasoline obtained from the T.B.P. still overhead of the synthetic crude. This graph shows that throughout its range, with the exception of the end point, the T.B.P. still overhead has higher boiling points than the battery gasoline; the end points, of course, being the same. Figure 8 shows a comparison of their true boiling point curves where the same difference is also shown.

Figures 9 and 10 show a comparison of the Engler distillation and the true boiling point curves of these two gasolines. As is typical of such curves the front end of the true boiling point curve is below the Engler distillation curve, while the rear end is above it.

CONCLUSIONS

The conclusions which may be drawn from this work are:

First, a true picture of the actual workings of a fractionating column is best obtained not by a comparison of the T.B.P. still work up of the charge itself, but by a similar work up of a blend of the products.

Second, results obtained with glass equipment charging small amounts of bottoms checked the more tedious and cumbersome methods of the larger T.B.P. stills. Therefore, it seems that determination of fractionating efficiencies with the glass equipment shown in Figure 3 is preferable, due to its rapidity and simplicity.

Some Factors in Engine Knock

A. W. TRUSTY
Louisiana Oil Refining Corporation

THE trend in automobile engine design has been toward a higher compression ratio in order to obtain fast acceleration, increased speed and greater power. This higher compression engine has made the refining industry, as well as the public in general, knock conscious. A discussion of the causes of detonation is given.

CAUSE OF KNOCK

The accepted theory for the cause of detonation is that it is the result of too rapid combustion of some portion of the charge. When the mixture of gasoline and air is ignited by the spark plug, burning takes place. The burning gas travels in a wave front which compresses the unburned gas before it. When this compression of the unburned gas reaches a point of sufficiently high temperature, the unburned gas explodes, causing an audible knock or vibration of the piston and metal parts.

The factors affecting detonation are varied, but temperature and pressure are the most important of the engine conditions, in fact, all of the other variables bear some relation directly or indirectly, to temperature and pressure. The variables affecting detonation may be listed as follows:

1. Fuel.
2. Compression ratio.
3. Temperature.
4. Engine Design.
5. Spark advance.
6. Mixture ratio.

COMPRESSION RATIO

Compression ratio is the ratio of the volume of the air-fuel mixture before compression to the volume after compression. For example a cylinder with a 3.28-inch bore and a 4.41-inch stroke has 37.2 cubic inches of volume before compression and 7.4 cubic inches of volume after compression. The compression ratio is 37.2/7.44 or 5:1. According to "Automotive Industries" March 10, 1934, page 305, the average car has changed in compression ratio as follows:

YEAR	Average R.P.M.	Compression Ratio	Piston Speed, Ft./sec.
1927	2740	4.55	2150
1928	2860	4.86	2210
1929	3063	4.99	2310
1930	3170	5.15	2380
1931	3230	5.23	2395
1932	3250	5.29	2390
1933	3360	5.57	2463
1934	3420	5.72	2508

James shows the effect of increased compression ratio on power: an increase from 4.0 to 4.8 ratio gives 14 percent increase in power and mileage, an increase from 5.0 to 6.0 ratio gives 10 percent increase in power and mileage, an increase from 6.0 to 7.0 ratio gives 7 percent increase in power and mileage. It is apparent that an increase in compression ratio much above 7 to 1 in the average automobile engine is not justified due to increased engine weight necessary for the increased pressure. It is probable then that a ratio of about 7 to 1 is the maximum that will be used in automobile internal combustion engines.

ENGINE DESIGN

Engine design has a marked effect on detonation. The shape of the combustion chamber, location of valves and spark plugs, water and air cooling surface, and materials of construction are examples. Kisline, Graham-Paige Motor Corporation, states that an aluminum cylinder head permits compression ratios about one unit higher than conventional cast iron for the same fuels. The ability of aluminum to conduct heat away from hot

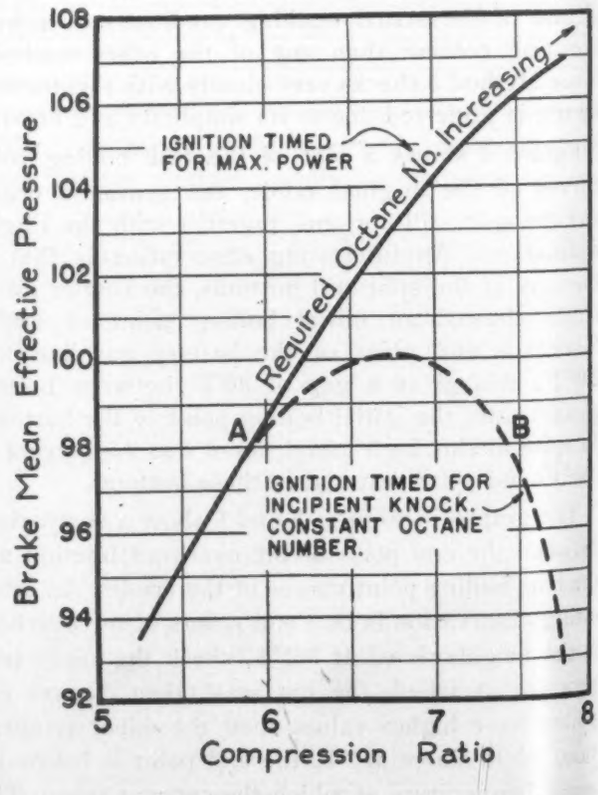


FIGURE 1

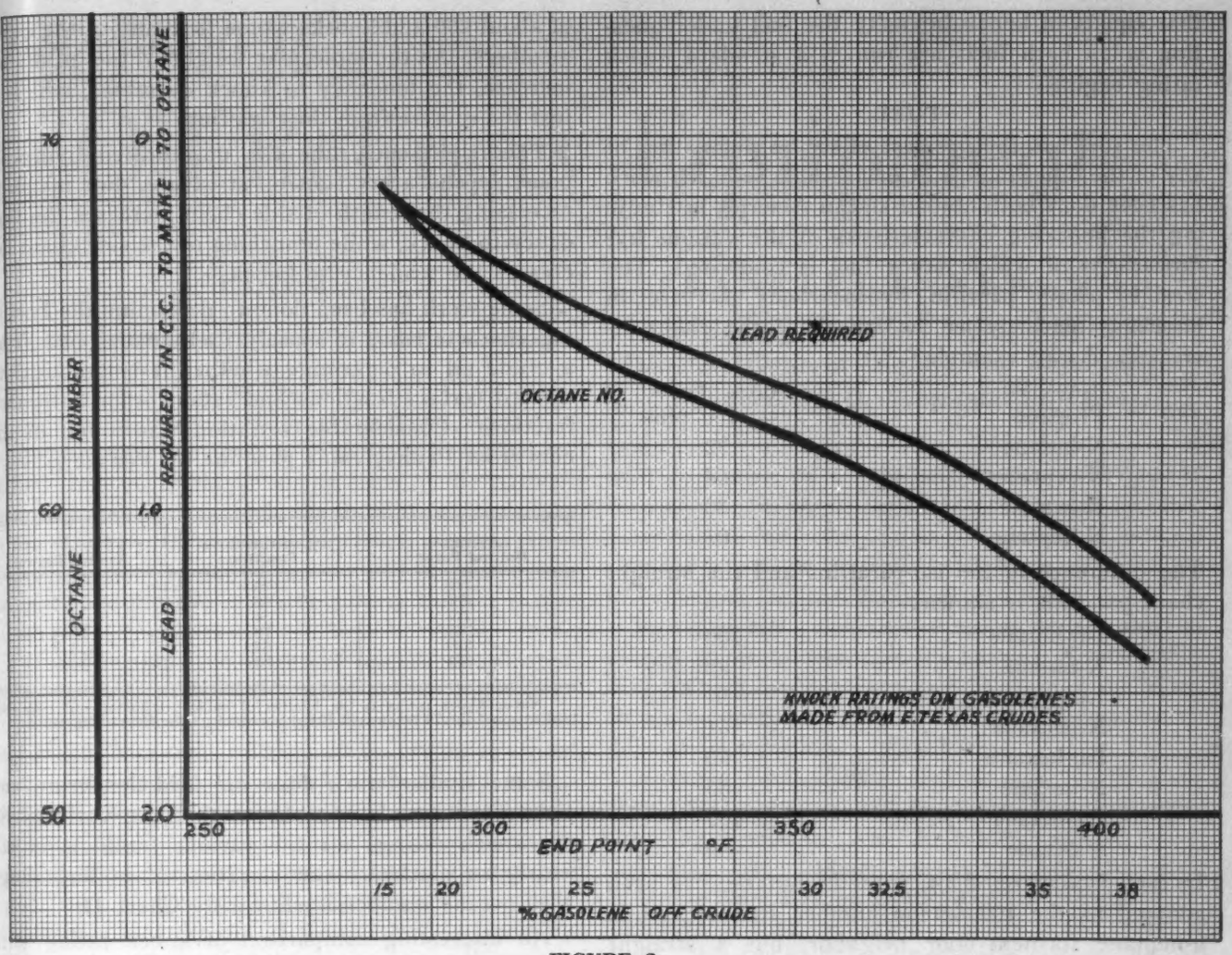


FIGURE 2

areas coupled with its higher specific heat is considered the explanation for this higher efficiency.

The change in the C. F. R. knock rating engine intake temperature well illustrates the effect of engine temperature on detonation. An increase in temperature of the air-fuel mixture from 90°F. to 300°F. has depreciated the ratings on some cracked gasolines as much as 6 octane number. The problem of improving cooling efficiency is of great importance for the engine designer.

SIZE OF CYLINDERS

The tendency of engine design is toward more cylinders of smaller bore. This trend is shown by the table:

Small pistons permit a higher ratio of cooling surface to piston diameter. The piston has little means of dissipating heat except through the lubricating oil and by contact with the water jacketed cylinder walls, and therefore operates at higher temperatures than the other combustion chamber surfaces. Any increase in piston diameter raises its operating temperature, and therefore raises the temperature of the compressed charge, thus causing increased knocking.

YEAR	4 Cylinder	6 Cylinder	8 Cylinder	12 & 16 Cylinder
1924	19.5	70.3	10.2	....
1926	13.0	66.0	21.0	....
1928	6.5	58.0	35.5	....
1930	2.9	43.3	52.8	1.0
1932	4.2	30.6	54.2	11.0

Note: Based on the number of models offered for sale.

SPARK ADVANCE

Retardation of the ignition timing serves to reduce detonation by causing the spark to take place so late in the cycle that the piston is moving downward as the last portion of the charge is burned, so that the volume occupied by the charge is increased and its temperature and pressure reduced. Chart I shows the effect of spark advance on detonation.

AIR FUEL RATIO

A lean mixture will not knock as much as a correctly proportioned charge of air and fuel due to the differences in temperature and pressure. A lean mixture, on combustion, will naturally give a lower pressure and temperature than a rich mixture. The spark advance and air-fuel ratio, however, should be adjusted for maximum efficiency, and no improvement can be made as far as reducing detonation is concerned.

OCTANE NUMBER

Octane number may be defined as the percent of iso-octane, in a blend of iso-octane and n-heptane,

that equals in knock intensity the fuel under question when both fuels are run in a standard knock rating engine.

FUEL

The fuel has the greatest effect on detonation of any of the other factors. Considerable research work has been done both abroad and in America in studying the knocking characteristics of the various hydrocarbons of which motor fuel is composed. The straight chain paraffin hydrocarbons increase in knocking tendency as the length of the chain increases. As an example:

Hydrocarbon	Octane Number
Propane	100 plus
N-butane	92
N-pentane	64
N-hexane	30
N-heptane	0

The difference in the iso-paraffins and the straight chain paraffins is shown:

Iso-butane	100
N-butane	92
Iso-pentane	91
N-pentane	64
Iso-hexane	60
N-hexane	30
Iso-octane	100
N-octane	—0

In fact, iso-octane, 2,2,4, trimethylbutane, has been adopted as the 100 octane number standard while n-heptane, its next door neighbor, but a straight chain hydrocarbon was adopted as the 0 octane number standard. To summarize then, the iso-paraffins have a much better antiknock value than the straight chain paraffins. Also, the more side chains an iso-paraffin has, the better is the anti-knock value.

The knocking tendency of the unsaturated hydrocarbons depends on the structure. The closer the double bond approaches the middle of the chain, the less the hydrocarbon knocks. As an example:

		Aniline Equivalent[1]
1—octane	C=C—C—C—C—C—C—C	—8
3—octane	C—C—C=C—C—C—C—C	6
4—octane	C—C—C—C=C—C—C—C	12
1—5 hexadiene	C=C—C—C—C=C	3
2, 4 hexadiene	C—C=C—C=C—C	26

Benzene, or benzol, the first member of the aromatic group of hydrocarbons, has an octane number of about 200 and knocks worse than any of the other members. As the molecular weight of the aromatics increase, the tendency to knock decreases, which is just the reverse from the paraffins.

The naphthenes, like the unsaturated hydrocarbons, depend a good bit on structure. For instance, increasing the length of side chain increases the tendency to knock, while branching of the side chain decreases the tendency to knock.

Some work has been done to determine the knocking characteristics of closely fractionated cuts from a crude oil to determine whether it is practical to discard certain fractions and retain other antiknock fractions. Considerable variation was found in the cuts from Pennsylvania gasoline by Fenske[1].

Average Boiling Point	% of Gasoline Fraction	Knock Rating
175	19	0
255	48	16.5
277	54	0
343	78	39.0
329	68	3.7
381	83	35.0

Note: Knock rating is the number of cubic centimeters of tetra-ethy lead to equal the 74 octane old Ethyl Standard on the Ethyl Engine.

Some similar work done on Mid-Continent and East Texas crude has shown that the variation in the knock ratings for the various fractions is not nearly so marked. The variation of boiling range with octane number is shown by Chart II.

An interesting comparison of knock rating with chemical analysis of gasolines is shown by the following table:

	Naphthenes	Aromatics	Unsaturates	Paraffins	Octane No.
Smackover, Strt-run	14.5	11.3	7.9	66.3	70
Smackover, Cracked	21.2	27.5	14.7	36.3	75
California, Strt-run	34.9	2.8	5.1	57.2	60
California, Cracked	16.7	22.0	23.0	38.3	76
Van Zandt, Strt-run	0	2.9	1.7	95.4	43
Van Zandt, Cracked	....	35.2	22.2	42.6	68
Penn., Strt-run	13.0	6.9	2.2	77.9	43
Penn., Cracked	10.2	23.5	9.7	56.6	68
V.P. cracked gas oil	10.0	35.0	55.0	0	80

Thus by cracking, and converting the paraffin hydrocarbons in Van Zandt crude to aromatics, naphthenes and unsaturates, the octane number is improved considerably. Smackover straight-run gasoline, which contains naturally hydrocarbons other than the paraffins, had a high octane number.

[1]Refiner, July, 1932.

Inspection of Oil Refinery Equipment

PART 3

FRANKLIN L. NEWCOMB

Supervising Engineer, Safety Inspection Division, General Engineering Department, Standard Oil Development Company

METHODS OF CONDUCTING INSPECTIONS—*(Continued)*

PIPING, valves and fittings have been grouped under one heading because all three are found together in a piping system and must necessarily be inspected together. In view of this grouping some of the methods described may not be applicable to all three items. As in the case of pressure vessels, a choice, of the method or methods to be employed, will have to be made by the inspector and this choice will be governed by the nature of the piping installation.

Visual-External—An external visual examination should be made of all visible parts to note atmospheric or ground corrosion as evidenced by rust, scale and pitting and to note signs of incipient failure as evidenced by cracking and/or distortion. Joints should be examined for signs of previous leakage, such as coke formations, oiliness, etc. On flanged hot lines particular attention should be given to the junction of the pipe and flange, since evidence of leakage at this point may indicate swedging of the end of the pipe with a possibility of the pipe pulling out of the flange. When flanges are backwelded to the pipe, examination should be made for cracks both in the weld and in the metal immediately adjoining the weld. Bolts used in pipe joints should be examined for corrosion, condition of threads, elongation and necking down and for cracks particularly at the junction of the head and shank. The fit of the nut on the bolt should also be observed, as an excessively loose fit is frequently a sign of over-stressing.

Visual-Internal—Insofar as possible, the interior should be visually examined, particularly noting any pitting, grooving, cracking, scaling, bulging or other irregularities or signs of weakness or over-stressing. In the case of valves, the seats and discs should be particularly examined for both corrosion and erosion, and to assure that they seat tight and will not leak. Valve seat rings should be examined to see that they are tight in the body so that leakage will not occur at this point.

Measurement of Wall Thickness—The wall thickness, of pipe near the ends, and of valves and fittings, may be determined by the use of either transfer or indicating calipers. In fittings particular attention should be given the wall thickness at points where change in direction of flow takes place. In gate valves, particularly if used for throttling, excessive reduction in thickness may be found in the bottom between the seat rings. Straight lengths of pipe may have the internal diameter measured by means of a tube micrometer when general corrosion or bulging is suspected or indicated by other examinations or tests. Sudden increases in internal diameter should be particularly noted as an indication of bulging or localized excessive corrosion.

Piping in any given service should be measured at several points to determine the amount of loss occurring. Where conditions are found to be bad, the piping should be opened at additional places to assure knowledge of its condition.

Hammer Test—Hammer testing pipe for thickness should not be confused with "sounding" to detect thinner areas by change in tone. In hammer testing pipe a sufficiently heavy hammer must be used and a sufficiently strong blow must be struck, to actually cause an indentation of the pipe wall if it is below the minimum limit. This test calls for considerable skill on the part of the inspector since each different limiting thickness requires a blow of different intensity. Only practice and experience can teach an inspector how to use this method. On the other hand, an inspector really experienced in this method of determining thickness will come surprisingly close in judging the exact intensity of blow required to determine a given thickness. It is a method which every inspector should acquire since it can almost always be employed when no other method of determining the wall thickness of pipe is feasible. *This method should never be employed while the pipe is in service or contains any flammable liquid or gas.*

Some inspectors also hammer test steel fittings but only to disclose excessively thin spots, since the limiting thickness of fittings is usually too great to be determined by this method.

Safety Drilling—As a supplement to wall thickness measurements and hammer testing, "safety drilling" may be employed. This consists of drilling small holes (3/32-inch or ⅛-inch) in the outer wall of the pipe or fitting to a depth just equal to the minimum allowable thickness. The drill used for this purpose should be sharply pointed so that when corrosion occurs to the bottom of these holes the first leakage will be very slight. These holes should be spaced closely enough to give a fair idea of the condition of the entire line and particularly at

points where experience has indicated the worst corrosion occurs. When leakage occurs through one of these holes it is known that corrosion has occurred to a point where the metal remaining is the minimum for safe operation. This method is particularly applicable to bends, flared type nozzles, large piping where joints cannot be readily opened for internal inspection, piping in inaccessible locations, etc. It is also applicable to pressure vessels which cannot be entered for good internal inspection.*

Hydrostatic Test—Pipe lines which can only be opened at infrequent intervals and which are too long for hammer testing may be given a hydrostatic test to get an indication of their condition. The pressure for such a test should be from one and one-half times to twice the normal working pressure of the line. After the line is filled and brought up to pressure it should be closed off and the time and pressure recorded. The line should then be inspected visually for its entire length, if possible, and any leakage should be noted. After an interval of fifteen minutes or more the pressure should again be observed. Any large pressure loss will indicate excessive leakage and the location of such leakage should be found. The amount of pressure drop permissible will be dependent on the service of the line but normally a loss of four or five percent in fifteen or more minutes should be considered creditable.

Air or Gas Test—Due to the possibility of freezing or the nature of the service in which the line is used, a hydrostatic test may not be feasible. In such case a pressure test with air or an inert gas should be used. The pressure employed in an air or gas test should not substantially exceed the working pressure of the line. To detect minor leaks, the joints may be painted with a soap and water solution and observed for bubbles. Where slight leakage is immaterial, it will usually suffice to listen for leaks and to feel around joints with the hands. Pressure drop should also be noted, the same as in hydrostatic tests, but the percent drop in pressure considered passable should be somewhat less.

Detection of Graphitization in Cast Iron—Under certain conditions, the iron content of cast iron will leech out, leaving the graphitic content intact. This is known as "graphitization." The wall of the casting will remain its original thickness, unless there is erosion, and the appearance of the material will not change other than to appear slightly darker. However, since the surface of a casting is usually stained with dirt, oil or other material, appearance, or visual examination, will not generally reveal this condition. Since this graphitic material has practically no strength it is important to determine the depth to which such deterioration has progressed. This material can be cut or scraped about as easily as the lead in a hard lead pencil. Therefore, scraping the surface of a casting with a pointed or sharpened instrument and applying a fair amount of pressure during the scraping should reveal this condition. If graphitization is indicated, it should be removed in spots until sound metal is reached. It should be borne in mind that the entire wall thickness can be graphitized and not be detected by visual examination. The condition may be caused by external conditions or by the material carried in the casting. Therefore, iron castings should be examined both internally and externally for this condition.

Piping, valves and fittings above ground around equipment should be inspected visually both externally and internally as far as possible. In addition, wall thickness measurements should be taken at all points where the line is open. Hammer testing should be generally applied to the piping over its entire length.

Long pipe lines, whether under or above ground should be opened every few hundred feet, examined visually at such points and wall thickness measurements taken. After reassembling, either a hydrostatic, or air or gas test should be applied. Pressure drop readings may have to be depended on almost entirely for an indication of the condition of long underground lines.

Cast iron pipe, fittings and valves should be examined for graphitization, particularly if underground in acid soil or if they carry sour products.

INSPECTION OF FURNACES AND FIRE BOXES

Furnaces and fire boxes should be given a thorough visual inspection both externally and internally.

The exterior should be examined for the following:

(a) Cracking, bulging, leaning or other signs of weakness or deterioration of the brickwork.
(b) Condition of burners and burner openings.
(c) Condition of inspection or ventilation doors.
(d) Condition of stack and external flues.
(e) Condition of steelwork such as buckstays, etc.
(f) Condition of header box compartments and doors, exterior tube sheets, and related equipment.
(g) Condition of furnace arches and arch supporting members.
(h) Condition of roof or shed over arch if such is employed.

The interior should be examined for the following:

(a) Cracking, bulging, leaning, spalling, fusing, loosening or other signs of weakness or deterioration of the furnace lining, interior brickwork and roof arch.
(b) Condition of interior tube sheets and tube supports.
(c) Condition of burner muffles.
(d) Condition of tubes (for details to be noted see "Methods Applicable to Furnace Tubes and Header Boxes—Visual-External").

Good maintenance of furnaces and fire boxes adds to the efficiency of combustion. Distortion or failures of the settings may set up strains in tubes or attached piping which may result in leaks, failures and fires.

CARE OF INSTRUMENTS AND GAUGES

Proper operation of equipment and, to a large extent, the safety of equipment is dependent on the condition and accuracy of the various instruments and gauges used. Since the adjustment and repair of the many

*Editor's Note—For details of the practice of Safety Drilling see, "Safety Drilling, Low Cost Insurance for Process Equipment" by Joel H. Hirsch, Refiner, Vol. 12, No. 5, May, 1933, page 184, and "Safeguarding High Pressure Equipment" by Luis de Florez, Refiner, Vol. 10, No. 12, December, 1931, page 75.

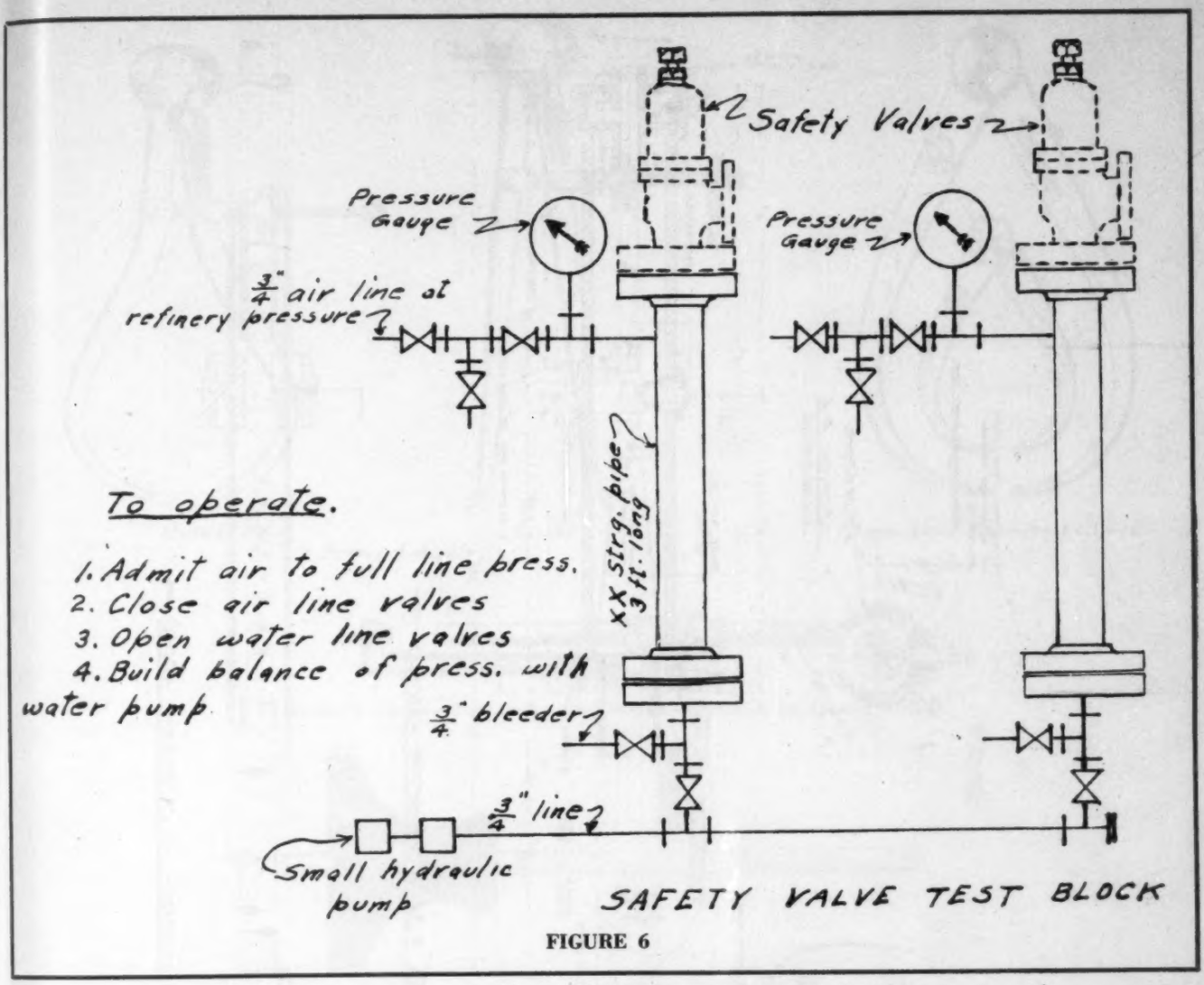

Safety Valves
Pressure Gauge
Pressure Gauge
3/4" air line at refinery pressure
XX Strg. pipe 3 ft. long
To operate.
1. Admit air to full line press.
2. Close air line valves
3. Open water line valves
4. Build balance of press. with water pump
3/4" bleeder
3/4" line
Small hydraulic pump
SAFETY VALVE TEST BLOCK

FIGURE 6

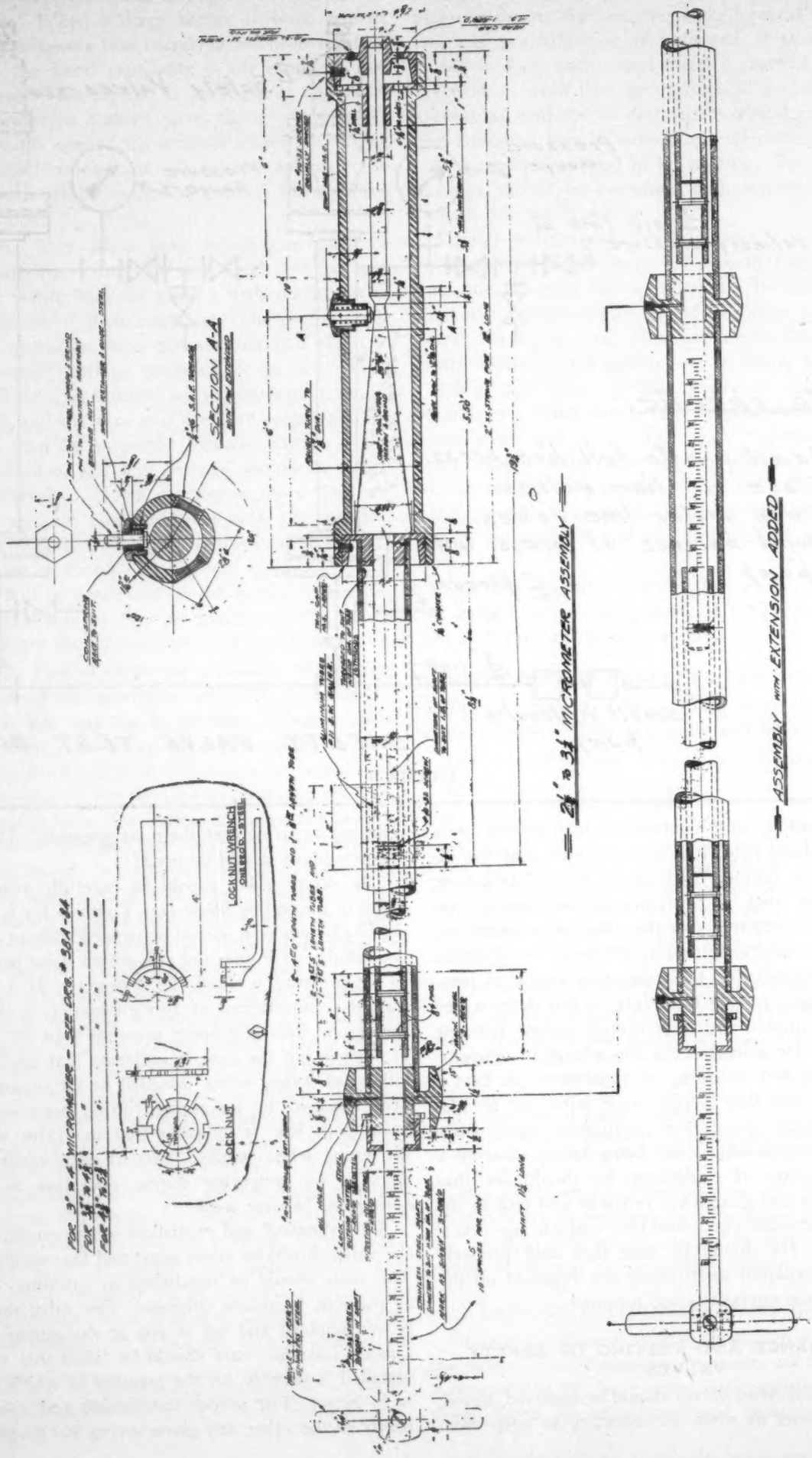
modern recording and controlling instruments is a highly specialized field, it is not expected that the inspector will be familiar with these details. However, he should see that all instruments and gauges are checked periodically to assure that they are accurate and in good mechanical condition at all times. In addition, he should ascertain that the connecting piping to pressure instruments is free and clear, is not deteriorated or otherwise unsafe and is protected against freezing if necessary. He should check the wiring to temperature indicating and recording instruments to see that it is not broken and that thermocouple wires are not detached or broken away from equipment, particularly where metal temperatures are being taken. During a general inspection of equipment, he should see that all instruments and gauges are removed and sent to the shop for an accurate check and test, and for any necessary repairs. He should be sure that only properly checked and repaired instruments are replaced on the equipment when operations are resumed.

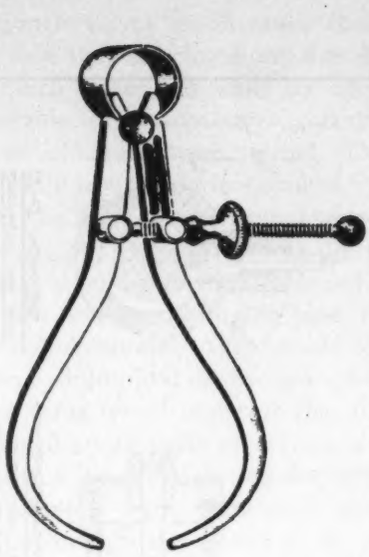
MAINTENANCE AND TESTING OF SAFETY VALVES

All safety and relief valves should be removed, tested, cleaned and reset as often as necessary to keep them relieving accurately at their set pressure. The following procedure should be used:

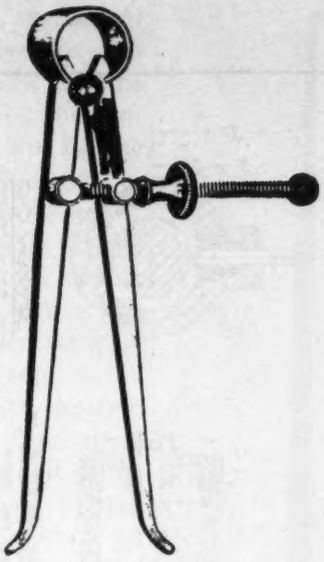
The safety valve should be carefully removed and taken to the testing block (see Figure 6 for typical testing block) where it should be popped without disturbing the setting. If it does not pop within three percent over its set pressure, it should be re-popped. If it was stuck due to accumulations of foreign matter, it should pop the second time at a lower pressure than the first time. If such is not the case, it indicates that the valve was either set wrong when installed or its adjustment has been changed, by tampering, during operation. If the valve pops low, it indicates that the valve was either set wrong when installed, that its adjustment has been changed by tampering during operation or that the spring has become weak.

After popping, and regardless of the condition found, the valve should be taken apart and thoroughly cleaned. The seats should be repolished by grinding, as lightly as possible, to assure tightness. The valve should then be reassembled and set to pop at the proper pressure. During assembly, care should be taken that the spring installed is suitable for the pressure at which the valve is to be set. For proper functioning and relieving capacity of the valve, any given spring has a very definite


SECTION A-A
LOCK NUT WRENCH
LOCK NUT
2½" to 3½" MICROMETER ASSEMBLY
ASSEMBLY WITH EXTENSION ADDED

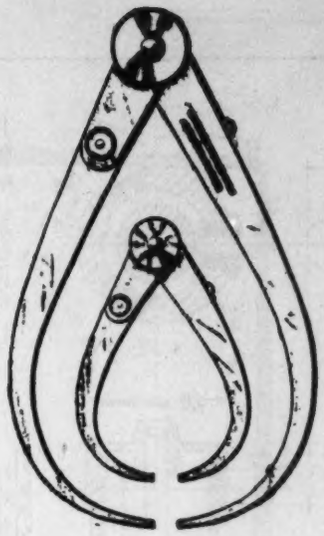


Outside



Inside

Spring Calipers



Lock Joint Transfer Calipers

Inspector's Gauge—Two-inch. Can be had four-inch on special order.

Depth Gauge

FIGURE 7

and limited range of pressure and checking this feature is important. It should then be tested for tightness by putting water on top of the seat and disc and admitting compressed air or inert gas under the seat until the pressure is within 10 percent of the set pressure of the valve. The water on top of the seat and disc should be carefully observed for bubbles as an evidence of leakage.

INSPECTION OF FIRE PROTECTION FACILITIES

General—Maps of the foam, high pressure water and steam smothering lines, showing the location and size of all pumps, mains, laterals, manifolds, valves, hydrants, etc., and the source of supply for each pump, should be obtained and checked with the equipment in the field, to see that they conform in all details.

Pumps—All pumps used for fire service should be inspected to see that they are properly lubricated, adjusted and generally maintained in first-class condition. A check of the relief valves should be made to determine whether they are sticking or have been tampered with, by operating the pump, closing down on the discharge valves and noting the pressure at which the relief valves operate. A slippage test should be put on each pump at approximately the normal operating pressure. In running the slippage test care should be taken that there is no leakage at the discharge of the pump. In addition to the slippage test, a service test of at least 15 minutes should be given each pump by running it at its normal speed and pressure. Some of the pumps can be given this service test by using them during the hydrostatic test of the lines.

Pump Houses and Rooms—All pump houses and rooms should be inspected to see that they are in a neat and orderly condition and in a proper state of repair.

Valves—The inspector should look over and open and close, or witness the operation of, each and every valve in the fire system. He should see that all block valves are properly marked for identification so that there will be no confusion when it is necessary to operate them in an emergency.

Hydrostatic Tests—A hydrostatic test, 25 percent in excess of the normal fire operating pressure, should be put on all parts of foam and high pressure water systems, including all hydrants. In testing foam systems,

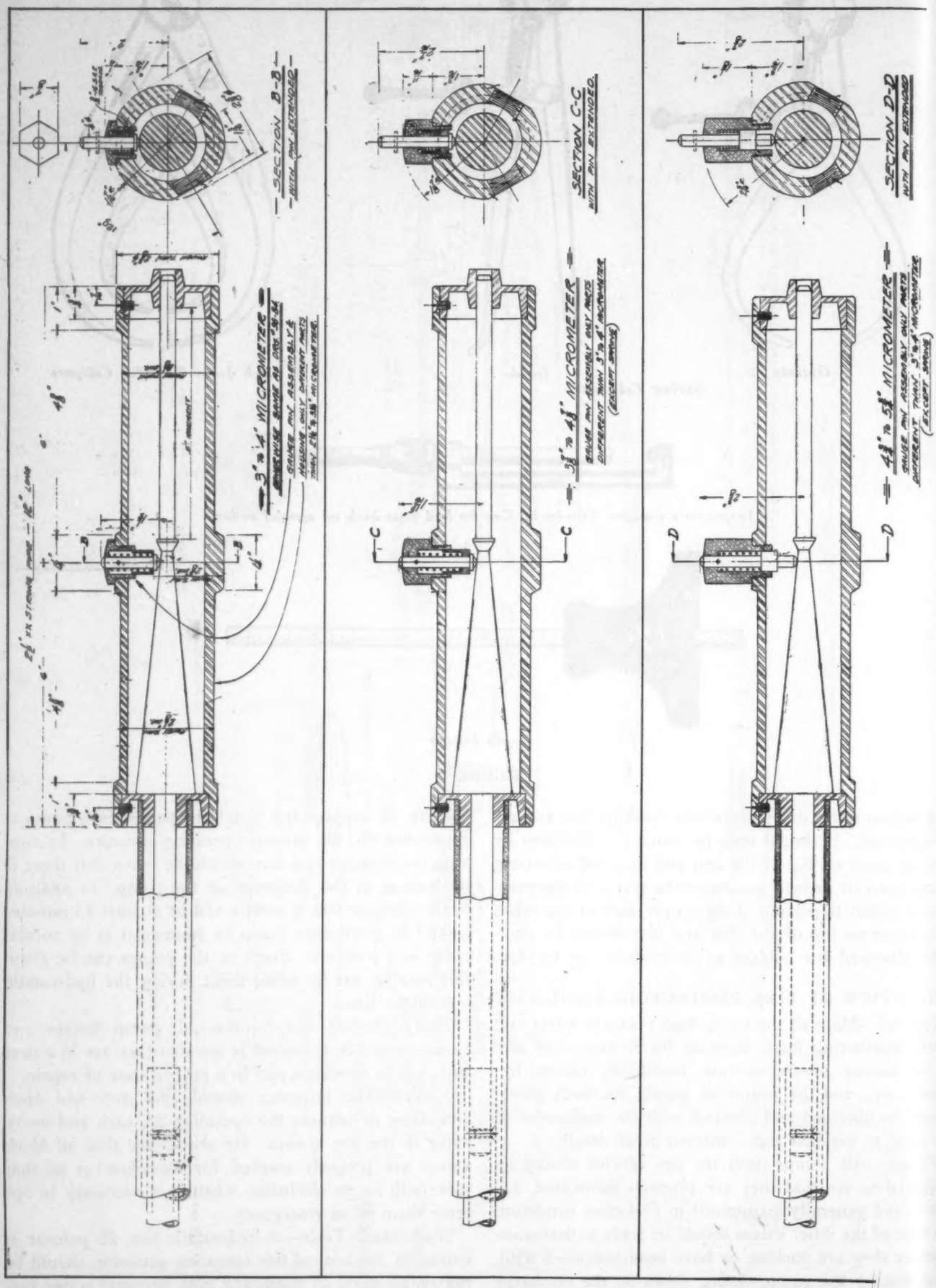

SECTION B-B
WITH PIN EXTENDED
SECTION C-C
WITH PIN EXTENDED
SECTION D-D
WITH PIN EXTENDED

FIGURE 10

the branch valves to all tanks should be checked to make sure they are closed and that drip valves between the branch valves and tanks are open, since it is often undesirable to get any water in certain tanks, the contents of which might be injured. The pressure for the hydrostatic test should be obtained by means of the fire pumps, the foam pumps being connected to a source of water for this purpose. While the pressure is on, the inspector should walk over each and every line, looking for leaks and breaks in the pipe, fittings, valves and hydrants. A suitable gauge should be tried on the most remote hydrant, and on various other hydrants, of the section being tested to assure that the desired pressure is attained on all parts of the system. All water spray lines should be tested during the hydrostatic test of the high pressure water lines and water should be discharged through the sprays in all locations where no damage will result. If defects are found, the hydrostatic test should be repeated after repairs are made.

On steam smothering lines, in lieu of the hydrostatic test, a full head of steam should be put in all mains and manifolds. Steam should be blown through all laterals, disconnecting them as near to the facility protected as possible if harm will result from discharging them into the facility. Care should be exercised during this test not to burn anyone who may be working on or in any of the facilities protected.

Foam Solutions—All foam solution storage and mixing tanks should be given a thorough visual examination to determine their condition. The solution storage tanks should be checked for outage to see that the required amount of solution is available.

Foam solutions should be checked for gravity and tested for expansion. To test for expansion, take 50 c.c. of each solution and bring to a temperature of approximately 70°F. Mix the two solutions by pouring simultaneously into a 1000 c.c. graduated cylinder, letting the streams mix at the lips of the beakers and fall together. Read the total expansion in c.c. Allow to stand, without jarring, for 30 minutes and take volume readings every five minutes. Solutions forming less than six volumes of foam (600 c.c.) or which show less than one half the original volume at the end of 30 minutes, should be considered unsatisfactory.

Miscellaneous—The entire fire fighting system should be inspected for orderliness and good housekeeping. Obstructions to valves, hydrants and hose houses or reels should be noted. A check should be made of all valves and hydrants to see that they are easily available and that all hazards are properly protected. Any connections made to the fire system for other than fire purposes should be reported.

The location, type, size and condition of all portable and hand extinguishers should be noted. All soda and acid, and foam extinguishers should be checked to see that they are fully charged and have been recharged within the specified time. The hose of all extinguishers should be examined for dry rot and plugging. All carbon-tetrachloride type extinguishers should be checked to see that they are full and operate properly. CO_2 extinguishers should be weighed to be sure they are full. When checking extinguishers, note their location for visibility and accessibility for the risk protected.

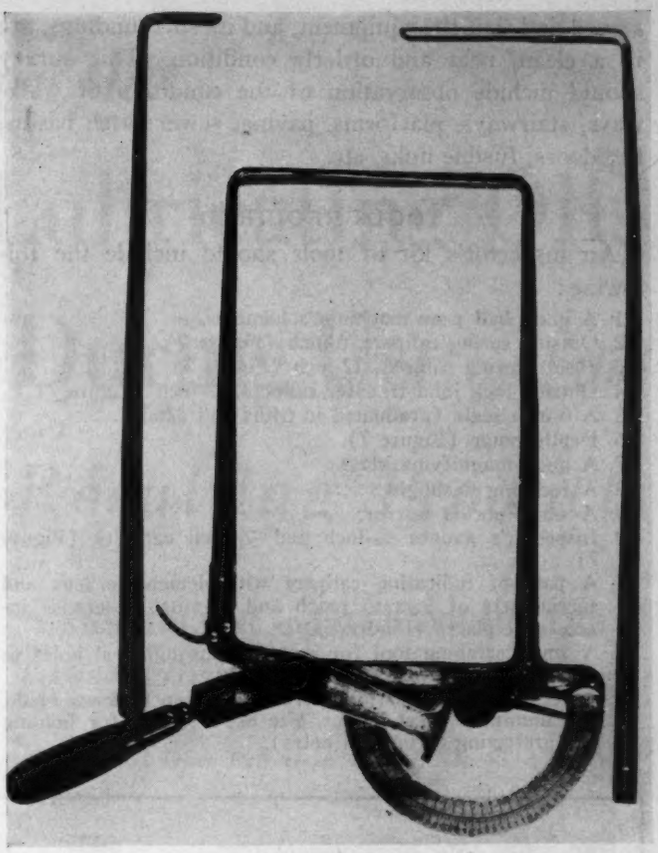


FIGURE 8
Indicating Calipers with Extra Legs

All rubber lined hose used for fire service should be hydrostatically tested at the maximum fire operating pressure. All equipment in hose houses should be checked to see that none is missing.

Sewer catch basins should be inspected to see that they are clear and will carry away water and spilled oil.

The condition of fire banks and walls should be noted.

Automatic fire doors should be tried to see that they function properly.

Foam generators should be inspected to see that they are in good condition and not clogged with rust or dirt. It is advisable to run water through them to see that the nozzles discharge a proper stream. Foam powder cans should be inspected to see that they are intact and not rusting seriously.

All potential fire hazards, such as: dry grass or brush around valves, manifolds and in tank fields, pools of oil, etc., should be noted so that corrective measures can be taken.

CHECKING FOR GENERAL SAFETY FEATURES AND HOUSEKEEPING

During the course of the inspection of any equipment, a survey should be made to see that all safety rules affecting construction and maintenance have been ob-

FIGURE 10

served and that the equipment, and its surroundings, are in a clean, neat and orderly condition. This survey should include observation of the condition of walkways, stairways, platforms, paving, sewer catch basins, fire doors, fusible links, etc.

TOOLS REQUIRED

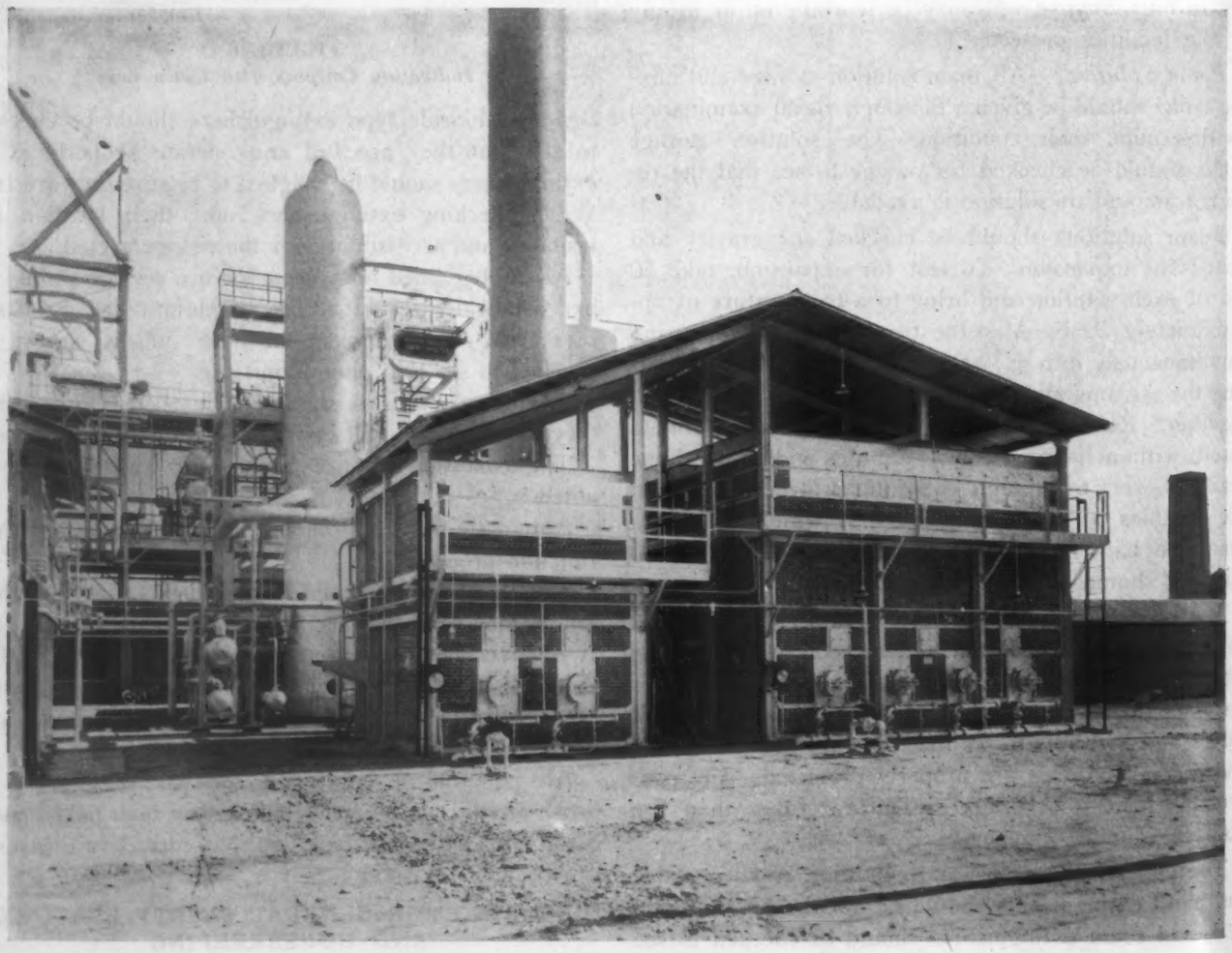
An inspector's kit of tools should include the following:

1. A good ball pean machinist's hammer.
2. Outside spring calipers, 6-inch (Figure 7).
3. Inside spring calipers, 12-inch (Figure 7).
4. Outside lock joint transfer calipers, 12-inch (Figure 7).
5. A 6-inch scale (graduated in 64ths and 32nds).
6. Depth gauge (Figure 7).
7. A good magnifying glass.
8. A focusing flashlight.
9. A small pocket mirror.
10. Inspector's gauges ½-inch and ¼-inch capacity (Figure 7).
11. A pair of indicating calipers with detachable legs and special sets of legs to reach and measure otherwise inaccessible places (Figure 8).
12. A small scraping tool for insertion through test holes to remove burrs, insulation and deposits.
13. A feeler and scraper made from a broken hacksaw blade.
14. An aluminum sheet holder, size 8½ x 11 in. (for holding and protecting forms and notes).

In addition to the above each plant should have a set of inside tube micrometers to fit all sizes of tubes in use (Figures 9 and 10).

Long rules, straight edges, tape lines, spirit levels, plumb bobs and other regular tools should be obtainable at the plant and, as they are used infrequently, are not considered a necessary part of an inspector's equipment.

Most of the tools mentioned above are standard equipment and can be obtained from tool supply houses. Those which are not standard equipment, and some which are standard but not commonly known, are illustrated and the illustrations give a sufficiently clear idea of their design to permit construction. Special legs for the indicating calipers will probably be designed by each inspector to meet special needs. Since such legs usually do not give a true reading on the caliper scale, some inspectors calibrate them and plot a curve for each set of special legs, drawing a picture of the caliper legs on each curve sheet so that the curve sheet for each set of legs can be easily identified visually. A little ingenuity in constructing such special legs will permit measuring thickness at places which at first may appear entirely inaccessible.



—Courtesy Foster Wheeler Corporation

New Furnace in a Texas Coast Refinery

Investigations Concerning the

Changes in Lubricating Oils During Use *and the Resulting Products*

HANS MULLER and WERNER MULLER
Technical High School, Dresden, Germany

Translated from *Petroleum Zeit.*, XXX 45, (1934)

THE tendency of lubricating oils to undergo changes and alterations in structure during use is generally attributed to three factors: namely, polymerization, auto-oxidation, and the precipitation of colloidal asphaltic matter or coloring matter. Auto-oxidation appears to be the foremost reaction, however, among the three mentioned. Nearly all methods of testing the stability of oils before they are put to use, therefore, take into account the peculiar action of oxygen upon mineral oils.

Since the products that usually result from aging or oxidation of the oil are acidic in character, the difference between the acid or saponification number of the original and the used oil is usually considered an index of the amount of change that has taken place. We have employed in our work the saponification number as a basis of several newly devised artificial aging tests, initiated in order to make a study of the various factors from all viewpoints which have to do with aging or change in the structure of oils.

The oil under test was placed in a flask, into which a steady stream of measured amount of air was blown, stirring the oil simultaneously, and holding it at constant temperatures. The flask was equipped with the usual type of water-cooled condenser to catch any light ends that might be driven off. The air used for blowing and oxidation is first dried by passing it through absorption towers of glass and filled with concentrated sulphuric acid, followed by one filled with calcium chloride, and in other cases where a definite amount of moisture in the air was desirable, the latter was bubbled through water. Using 400 liters of air per hour, 100 grams of oil, for instance, were treated at 95°Cent. for 8 hours, during the addition of various amounts of oil, in some cases, to make up for the loss of oil during blowing. In general, it was found that the saponification value had risen four-fold.

The increase in saponifiable matter is not appreciably influenced by the addition of finely divided metals, in quantities of approximately one percent, but is influenced quite plainly by the metallic oxides and the heavy metal salts of the fatty acids. A most important factor, as one might expect, toward obtaining high saponification numbers is the stirring or the rapid motion of the oil during oxidation in the flask. The oxidation of the oil was appreciably held back by the presence of large amounts of water-vapor in the air used for blowing, and again by the use of a series of organic chemical compounds, added to the oil in concentrations of one-tenth percent.

The following substances were added to oils and were without effect: Malonic acid, benzonitril, toluolnitril, amyl alcohol, glycol, glycerine, benzaldehyde, acetylacetone and cyclohexanol.

Those which rapidly speeded up the oxidation of the oil are: palmitic, stearic, cerotic and oleic acids.

Oxidation was somewhat retarded by: Nitraniline, p- and m-phenylendiamine, urea, semi-carbazide, guanidine, and alpha and beta naphthylamine.

Those compounds showing a marked effect on reducing the tendency for oils to oxidize are: Resorcinol, pyrogallol, phloroglucine, alpha and beta naphthol, p-nitrophenol, borneol and Japan camphor.

There is no clear distinction being made at present concerning the substances formed during such alteration going on in an oil during use or blowing with air. One can surmise that the oxidation of the lube oil eventually leads to the formation of aldehydes, acids, and lactones by way of the intermediate-formed compounds—the ozonides and the peroxides. These compounds when of fairly low molecular weight, such as acetic, formic, valeric acid and aldehyde are of course lost or are not recoverable from used oils since their boiling points are below that at which the oil is being used in practice. Reference is made especially to industrial lubricants. The products of a more far-reaching oxidation or the gaseous compounds formed in an internal combustion engine such as formaldehyde, carbon monoxide and carbon dioxide are likewise not obtainable from a used or

so-called aged oil. The work of Frank has shown that the formation of tars or tarry matter has a close connection with the formation of lactones, rather than due to the presence of naphthenic or asphaltic acids. Marcusson furthermore claims the formation of oxynaphthenic acids.

Below are shown the tests of an auto oil before and after use:

ORIGINAL OIL	
Color	red, green cast.
Precipitate	None
Water	None
Solubility in 86 Be. naphtha	Totally soluble
Viscosity at 68°F	150.1° Engler
Viscosity at 122°F	15.67° Engler
Acid Number	0.01
Saponification Number	0.13

USED OIL	
Color	Black, no fluorescence
Precipitation, Opaque, and contains a slimy deposit	
Water	Traces
Solubility in 86 Be. naphtha, Not completely soluble	
Viscosity at 68°F	109.7° Engler
Viscosity at 122°F	13.8° Engler
Acid Number	0.52
Saponification Number	1.63

In order to isolate the oxidation or reaction compounds, the used oil was extracted with caustic soda solution. This alkaline extract was next further extracted with 86 Be. naphtha, which resulted in an extract containing the hydrocarbons that have undergone the changes during use or blowing. The hydrocarbons could be further resolved into solid and liquid fractions. The acids obtained from the liquid portions, by acidification with hydrochloric acid are insoluble in water, but are soluble in alcohol, ether, benzine, benzole and chloroform. They can be further precipitated from their ammonia soaps by copper sulphate, silver sulphate, and by the cholorides of lithium, calcium and magnesium. The copper salts are soluble in light petroleum naphtha yielding beautiful green colored solutions. The formolite reaction is negative. The solid extracts are yellow powers, insoluble in water, difficulty soluble in ether and alcohol, but are completely soluble in chloroform and carbon tetrachloride. The material is insoluble in aqueous ammonia and caustic solutions; upon heating the caustic solution, however, the powder finally dissolved slowly. The constants shown below have been determined for both the liquid and solid extracts:

	Liquid Extract	Solid Extract
Acid Number	84.86	96.45
Saponification Number	211.8	215.4
Iodine Number	50.32	23.42
Molecular Weight (Rast)	261.7	383.6
Percent Hydrogen	8.83	7.12
Percent Carbon	42.64	66.92
Empirical Formula	$C_nH_{2n-8}O_8$	$C_nH_{2n-12}O_6$
Number of Carbon atoms in Molecule	15-16	23

For further investigation, methods were evolved to separate the above two fractions still further, such as by chlorination, with sulphur oxycloride ($SOCl_2$), and fractionation of the chloride, or esterification with fractional distillation, as well as an examination of the lime, lithium, silver and copper salts. Of these various methods, the one best adapted to this work is based on the separation due to the different solubilities of these salts. An acidic constituent from the potassium and lithium salt showed an acid number of 163, and iodine value of 60, which decreased to 30 after letting the sample stand for some time. Later on in our work, we isolated an acid which could not be precipitated by potassium lithium or magnesium chloride. This organic acid showed:

Acid Value	361
Molecular Weight	154
Iodine Number	26.0
Percent Carbon	63.3%
Percent Hydrogen	5.0%
Percent silver in the silver soap	42.0%

The copper salts colored the benzine again a deep green and were soluble in the usual solvents such as alcohol and ether. From the above the formula has been calculated as being:

$$C_8H_8O_3$$

This has been substantiated by an analysis of the silver salt.

The above results further strengthen our views that oxyacids are the principal acidic substances that form during the aging or oxidation of petroleum lubricants.

In conclusion we wish to express our thanks to Dr. Prof. Ed. Graefe, who supplied us with the various oils and materials, and who assisted us in pointing out certain important phases of this work.

Alloyed Cast Irons

In Petroleum Refining Equipment

PART II

J. S. VANICK

Research Metallurgist, International Nickel Company, New York

WHERE machinability is unimportant as for firebox and still tube supports, which are not excessively heated or loaded, alloy additions to low silicon (under 1.50) irons containing from 1.25 to 2.50 percent nickel and .60 — 1.0 percent chromium give good results. (Table XVII.)

The upper alloy ranges shown in Table XVII produce a hardening of the cast iron which limits the degree of heat resistance obtainable, particularly where machinability is important and the improvement illustrated by tables XI, XIII and XIV can then be excelled only by employing one of the high alloy types of cast iron such as Ni-Resist, which is described more fully, later.

TABLE XVII

Composition range for non-machinable, non-pressure, moderate heat resistance, castings.

Total Carbon	3.10—3.25%
Silicon	0.75—1.50%
Manganese	0.60—0.80%
Nickel	1.00—2.50%
Chromium	0.50—1.25%

The nickel-chromium cast irons illustrated in Table XVII in the relatively simple composition shown, and in about a 1 to 1½-inch section would be completely destroyed in about 12 to 15 months at 1100°F., while the plain cast iron would fail in about six months. Several courses remain open to deal with this problem.

First, limit the working temperature to a maximum of 900°-1000°F.

Second, employ about twice the alloy content, i.e., 3 to 4 percent nickel with 1 to 1.25 percent chromium to obtain a corresponding improvement.

Third, use Ni-Resist, which, as described later, possesses 8 to 12 times the resistance to deterioration shown for plain cast iron and may be employed for somewhat higher temperatures than 1100°F.

Fourth, equip entirely with heat resisting alloys of the steel type, such as shown in Table XVIII.

These separate suggestions require a little amplification. The second one, recommending a 4 percent Ni 1.25 percent Cr type of cast iron is being employed as kiln liner in the cement industry where its hardness helps resist abrasion as well as heat. It should not be employed if extensive machining is necessary because its hardness may exceed 350 Brinell, although it is gray and possesses the toughness of gray cast iron in comparison to the brittleness of white non-graphitic irons.

If high degree of permanence is necessary the Ni-Resist composition, austenitic, non-magnetic and corrosion resistant as well as machinable can be applied for temperatures above 600°F. and under 1300°F. as shown in Tables XI, XIII and XIV, Figures 10 and 11 taken from Woods[8] work. After making a growth test on a series of commercial materials, Wadman[9] selected Ni-Resist for furnace parts heated at 900-1300°F. and heat resisting alloys for higher temperatures. Results of his tests appear in Figure 15.

The toughness of Ni-Resist is considerably greater than that of ordinary cast iron, as indicated in the impact data above, as well as in deflection tests. Its strength is about the same as that of plain cast iron and at best reaches a 30 to 40,000 p.s.i. tensile level. At elevated temperatures, quick or short time tests (Figure 13) show that its strength falls rapidly in the range of 800-1400°F. as is true of all cast iron base materials, but most important, in connection with its use at elevated temperatures is the fact that its strength remains unchanged, while the low alloyed irons and plain irons deteriorate with time until a few months service at high temperatures destroys their strength and body completely as shown in Tables XII and XIII. Summarizing these facts, and outlining suitable compositions, assuming a normal 1-inch section, suggests the following table:

TABLE XVIII

Firebox and Still Castings*

Temp ° F.	TC	Si	Ni	Cr	Type
A—up to 600	3.10-3.40	1.20-1.75	...	...	Plain
B—600-900	3.10-3.40	1.20-1.75	2.0	.75	Cu Ni-Cr
C—900-1300	2.60-3.10	1.50	14.5	3.50	6.0 Ni-Resist
D—1300-1800	Under .35	.....	10-12	24-28	Heat Resisting
E—1800-2000	Under .35	.....	35	15	Heat Resisting

*Tube supports, firebox castings, dampers, stack rings, etc., Heat resisting alloys D and E are used interchangeably depending upon condition of atmosphere, particularly of sulfur, in furnace.

[8]T. J. Wood, Cast Iron at Elevated Temperatures—Iron Age, page 132, July 13, 1933.

[9]H. A. Wadman, Corrosion and Heat Resisting Ni-Cu-Cr, Cast Iron Trans. A.S.S.T., 1930, page 935.

CORROSION RESISTANCE

Almost every conceivable form of corrosion is encountered in refinery operation. Acids, caustics, saline solutions, liquids, tars, hot, cold, aerated, agitated, turbulent, stagnant, erosive, vapors, wet, dry, represent some of the conditions encountered. Fortunately, nearly all of the mildly alloyed nickel or nickel-chromium cast irons possess a moderately good resistance to most corrosives. Some of the improvement is due to the inherent resistance conferred by the alloys; the remaining improvement comes from an attendant refinement in the structure and texture. Many castings, such as condenser pipe sections, fittings, manifolds, traps, regulator valves, pumps, bubble caps and trays, etc., are moderately alloyed to obtain a mild increase in corrosion resistance ranging from 20 to 200 percent. In most cases light castings, such as thin walled pipe or condenser castings, etc., will contain:

Thickness	TC	Si	Ni	Cr
⅛–½″	3.10–3.40	1.80–2.20	.50	.20

Heavier castings, such as pumps, bubble caps, valves and control devices will contain three times as much alloy to compensate for their thicker section, viz:

Thickness	TC	Si	Ni	Cr
½–2″	3.0–3.40	1.20–2.00	1.50–2.5	.50–.75

When chromium or silicon are not particularly useful as in caustic, hydrochloric, or similar corrosives, chromium free low silicon compositions may be most useful, viz:

Thickness	TC	Si	Ni
⅛–1″ 1–3″	3.1 –3.50 2.80–3.40	1.40–1.80 .60–1.40	1.0–2.5 2–4.5

Where conditions are especially severe the Ni-Resist composition of the nickel-copper-chromium or copper-free type are employed, viz:

Section	TC	Si	Ni	Cu	Cr
⅛–1″	2.60–3.10	1.40–1.80	13–15	5–6	1.50–2.50
Copper Free	2.60–3.10	1.40–1.80	18–22	Under .30	2–3
1–2½″	2.60–3.10	.60–1.40	13–15	5–6	2–3.50
Copper Free	2.60–3.10	.60–1.40	18–22	Under .30	2–3.5

In many instances the character of the corrosives encountered defy definition. They may be mildly acid one day and caustic or brackish the next. In such cases a great deal of useful data has been obtained by means of the corrosion spool test. In this test, a series of cast iron specimens are prepared, weighed and mounted on an insulator with insulating spacers between them to eliminate electrolytic or galvanic corrosion. After a long enough period of exposure to eliminate the effects of day-to-day variations, the spool is removed and the specimens, cleaned, weighed and critically examined. In some cases the advantage of one composition over other is

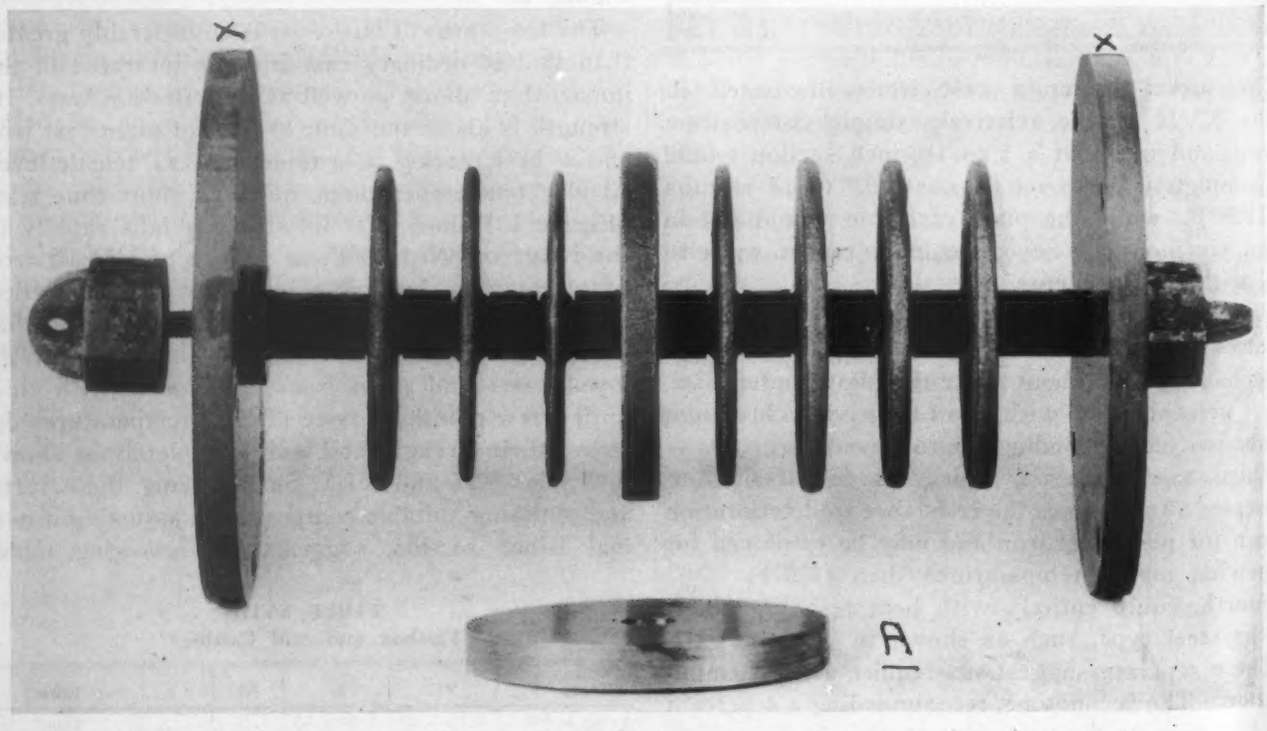


FIGURE 15

Results of 78 days test of cast iron in acid-treated naphtha stream. Disc A is original size of test specimens. Discs X X are Basalite end rings. All specimens originally same size as specimens A. Thick specimen in center of spool is Ni-Resist.

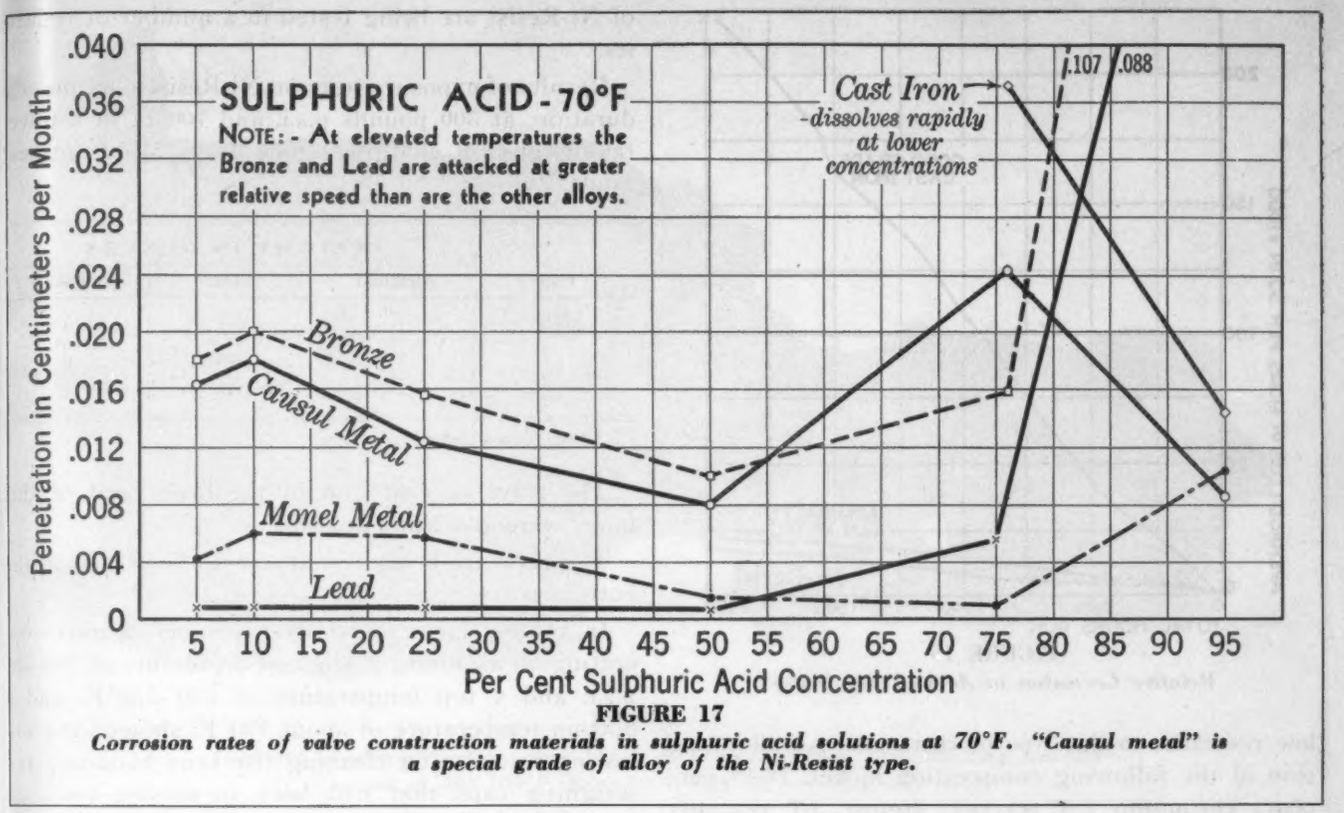


FIGURE 17

Corrosion rates of valve construction materials in sulphuric acid solutions at 70°F. "Causul metal" is a special grade of alloy of the Ni-Resist type.

so distinct upon visual inspection that further work is hardly necessary. Figure 16 illustrates this. The superior performance of Ni-Resist in these pilot tests lead to its gradual introduction and finally widespread adoption for many refinery applications. Its greater resistance to wear, Table XIX over the ordinary cast irons or the soft brasses and bronzes, and its ability to endure hotter temperatures rapidly increased its commercial usefulness. Ni-Resist worked well against most corrosives whether acid base or salt, and the ever-shifting character of some refinery solutions made it more or less an all-purpose, low cost construction material. Figures 17, 18 and 19 indicate its acid, caustic and salt water performance. A summary of tests upon typical refinery corrosives has been separately prepared.[10] Cooper-Bessemer Corporation prior to its application of Ni-Resist for compressor heads, cylinders and pistons made the test summarized in Table XX.

Shaffer and Pollock reporting upon extensive tests of condenser materials, wrote:

"A few ferrous alloys tested in the stream from distillation of acid treated naphtha showed that metals of the 18-8 (chromium-nickel) type show good resistance and that cast iron is more resistant than steel, while small additions of copper to cast iron appear to lessen its resistance; low chrome steel shows only

[10]The Petroleum Industry Applies Ni-Resist—The International Nickel Company, Section 1, No. 4.

TABLE XIX

Weight Loss of Austenitic and Ordinary Cast Irons Under Erosive Conditions (Mather and Platt, Ltd.)

MIXTURE	"Ni-Resist" Type Alloy	Cast Iron
Sand and water 50–50	145	320
Coal dust and water 50–50	18	84
Clinker and water 50–50	144	320

TABLE XX

Weight Loss—Grams Per Square Meter Exposure[11] to Saturated Hydrogen Sulfide in Water at 180°F.

MATERIAL	100 Hours	200 Hours	300 Hours	400 Hours
"Ni-Resist"	59.68	83.45	83.45	83.45
Semi-steel (12½% steel)	79.05	189.10	221.65	248.00
Piston-ring cast iron	156.55	215.00	252.65	294.50
Machine steel (0.35 to 0.45% carbon)	85.25	217.90	310.00	362.70

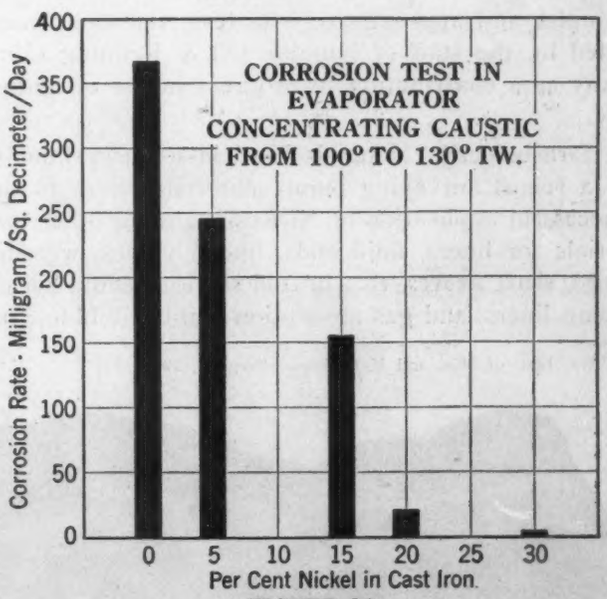


FIGURE 18

Effect of Nickel Additions to Cast Iron. "Ni-Resist" of 20 percent Nickel—2 percent chromium resists boiling caustic corrosion

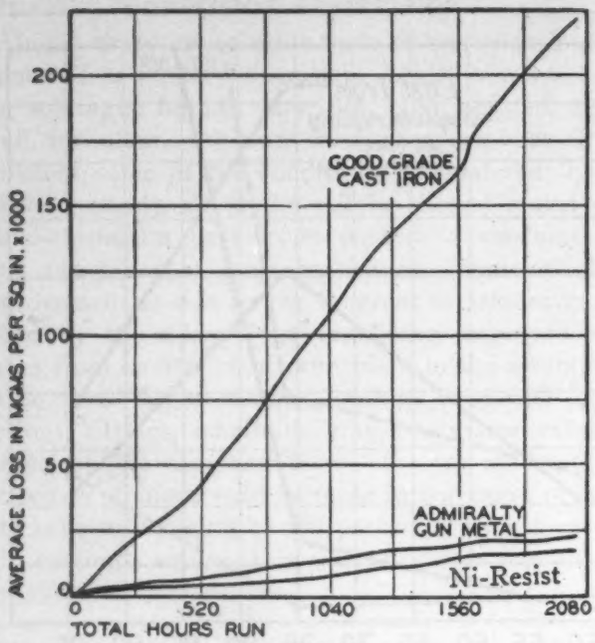


FIGURE 19

Relative Corrosion in Aerated Sea Water

low resistance to this type of corrosion. An alloy cast iron of the following composition nickel, 12-15 percent; chromium 2-4 percent; copper 5-7 percent; silicon 1.5 percent; total carbon 3.0 and the remainder iron, has proved very resistant in such a service. Cast iron, on account of its low cost and moderately long service, is reasonably economical, but a trial of the above alloy may justify the higher capital expenditure."

More recent work by Pollock, Camp and Hicks was reported in the 1935 February A. I. M. & A. I. M. E. Symposium on "Metals in Oil Refining Equipment." An attempt to abstract some of the data on cast iron is made in Table XXI, but for complete information the reader is referred to the 200 or more samples and approximately 35 test conditions compiled by the staff of Humble Oil & Refining Company as a contribution to progress in the oil industry.

Harnsberger[11] "Materials Used in Refinery Pumps" in a report surveying pump materials refers to the successful application of Ni-Resist among other materials for liners, fluid ends, liners, valves, wearing rings, shaft sleeves, etc., in cold service, reflux, hot oil pump liners, and gas absorption plants. Bubble caps of Ni-Resist are being tested in a number of refineries.

Results of exposure tests on Ni-Resist—six months duration, at 300 pounds p.s.i. and 700°F. in a tower taking gas oil charging stock from Mid-Continent crude.

Cap	WEIGHT IN OUNCES		
	Original	Final	Loss
Top	180	179	1
2	180	178	2
3	180	174*	6*
4	176	176	0
5	175	173	2
6	182	178	4

*Weight loss includes broken tooth.

The trays of cast iron in the lower end of this tower were also badly attacked.

The tests are being repeated with Ni-Resist in the bottom trays.

In another large midwestern refinery, a tower operating on all kinds of stock at a pressure of 300-350 p.s.i. and a top temperature of 650°-750°F. and a bottom temperature of about 750°F. showed the following results after cleaning (by sand blasting) and weighing caps that had been in service for 3135 hours:

Tray No.	Average Weight Loss Oz. Per Cap		Ratio of Corr. C. I. vs Ni-R
	Cast Iron	Ni-Resist	
Top	12	4	3.0
2	14	6	2.4
3	17	8	2.2
4	Broken	12	...
5	22	11	2.0
6	24	7	3.4
7	21	7	3.0
8	20	8	2.5
9	23	6	3.9
10	22	11	2.0
11	23	10	2.3
Bottom	19	9	2.2
Avg. (excluding #4)	19.7	7.9	2.5

Caps had been grouped in accordance to their positions on each tray and average weight losses measured. In addition, observations were recorded to the effect that nearly 25 percent of the plain cast iron caps were cracked or broken and that all caps were badly pitted, indicating localized corrosion of greater severity than registered by the average weight loss. The caps have been replaced and will be corroded to destruction. The tests thus far indicate that a further advantage over the two to four-fold improvement will accrue to the Ni-Resist caps, as their better sur-

[11]Am. Inst. of Min. and Met. Engs.—Preprint, 1935.

FIGURE 20

Condition of eight-inch pipe after several months handling hot, hydrogen sulfide contaminated brackish water

FIGURE 21

Corroded condenser section after 1½-2 years in condenser box handling gasoline vapors at 600-700°F. Exterior cooled by brackish well water

TABLE XXI
Results of Refinery Corrosion Tests

Penetration in inches per year.

No.	Type	Fresh Water	Salt Water Condenser Box	Salt Water Condenser Box	Steam	Crude Oil Vapor	Naphtha (Liquid)	Cr. Coil Bubble Tower	DEBUTANIZER		5% HCL. 13,700N.	5% HCL. Plus Acid Sludge
									Vapor	Liquid		
70	Plain.....	.0005	N. D.	.0044	.0089	.0136	.0111	.0054	N. D.	N. D.	3.6813	.0975
139	Low Silicon....	.0029	.0154	.0046	.0090	.0066	.0057	N. D.	.....	.....	.....	.....
116	C. N. I.....	.0019	.0074	.0047	.0061	.0144	.0060	.0051	.....	.....	.....	.....
179	Ni 4%.....	.....	.....	.0037	.....	.0037	.0120	.0078	.....	.....	.....	.....
173	Pipe.....	.....	.....	.0046	.....	.0090	.0084	.0051	.....	.....	.....	.....
71	12½ Ni Special	.....	.0078	N. D.	.0024	.0046	.0053	.0001	N. D.	N. D.	.3297	.1563
117	Ni Resist.....	.0001	.0030	.0036	.0001	.0145	.0022	.0030	.0001	.0003	.0456	.0312

No.	Type	Plant Caustic 15° BE.	Wash Water From Treaters	Wash Water From Treaters	Wash Water From Treaters	Rerun Naphtha Acid Treated Still (Vapors)	Rerun Naphtha Acid Treared Still (Liquid)	Plant Caustic 10° BE.				
117	Ni Resist.....	.0002	.1330	.0172	.0285	.0003	.0004	.0002	.....	.....	.....	.....
158	88-10-2 Bronze.	.0006	.0155	.....	.0135	.....	.....	.0027	.....	.....	.....	.....
A-3	77-8-15 Bronze.	.0013	.0246	.0087	.0157	.....	.....	.0007	.....	.....	.....	.....
70	Plain.....	.....	.....	.....	.....	.0018	.0057	.....	.....	.....	.....	.....

Analyses

No.	Type	IC	Si	Mv	Ni	Cr	Cu	Sv	Pb			
70	Plain.....	2.61	1.75	.95	.....	.....	.....	.....	.....	.....	.....	.....
139	Plain.....	3.0	2.0	.60	.....	.....	.....	.....	.....	.....	.....	.....
116	C. N. I.....	3.30	2.40	.65	.40	.25	.....	.....	.....	.....	.....	.....
179	1 to 4% Ni....	.....	.....	.....	1—4	.....	.....	.....	.....	.....	.....	.....
173	Pipe.....	3.40	1.80	.....	.....	.....	.....	.....	.....	.....	.....	.....
71	12½ Ni Special	2.78	2.17	.47	12.41	.....	.....	.....	.....	.....	.....	.....
117	Ni Resist.....	2.80	2.0	1.0	13 to 15	2 to 3	5 to 6	.....	.....	.....	.....	.....
178	Ni Resist.....	2.80	2.0	1.0	13 to 15	2 to 3	5 to 6	.....	.....	.....	.....	.....
A-3	Bronze.....	.....	.....	.....	.....	.....	77	15	8	.....	.....	.....
158	Bronze.....	.....	.....	.....	.....	.....	88	10	2	.....	.....	.....

No. 17 Under-alloyed Ni Resist Type.

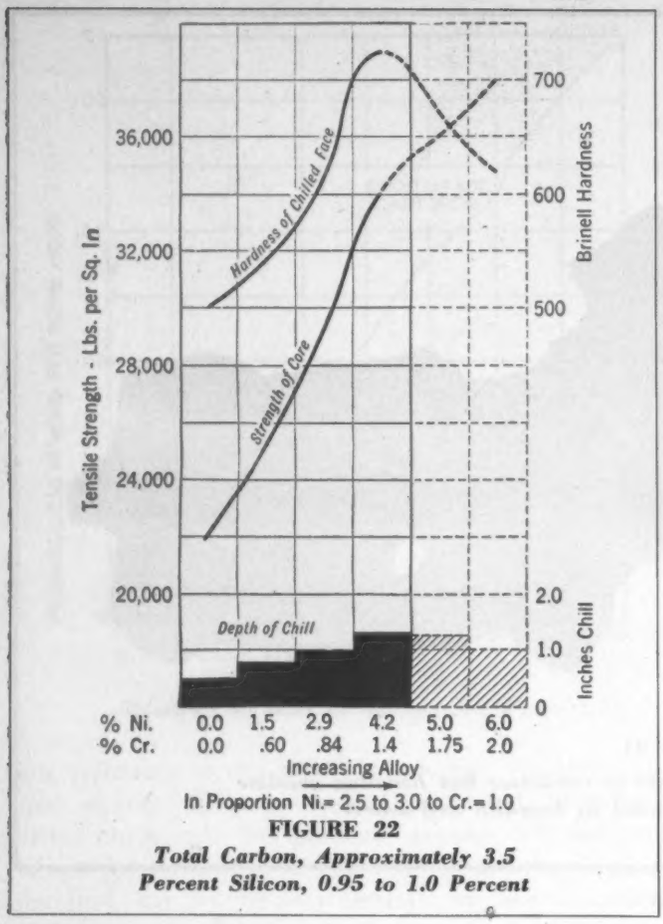


FIGURE 22

Total Carbon, Approximately 3.5 Percent Silicon, 0.95 to 1.0 Percent

face condition resists the reception and retention of corrosive vapors.

Condenser corrosion is a troublesome matter in many refineries, especially in the top sections where temperatures are high and the vapors begin to be converted into liquid. Figures 20 and 21 show some of the conditions of corroded pipe and condenser sections after a short time in service. Condenser sections, pipe, pumps, valves, meters, traps, filters, bubble caps, etc. are typical castings regularly being produced of Ni-Resist.

ABRASION RESISTANCE

An extremely hard, white cast iron, unmachinable and possessing when sand cast, a hardness in excess of 600 Brinell, has been developed and trade named "Ni-Hard." It contains approximately 4 to 5 percent of nickel and 1.5 to 2.0 percent of chromium and is achieving increasing importance in castings subject to abrasive conditions.

A comparison of its strength and hardness with plain cast iron is shown in Figure 22. Its properties are summarized in Table XXII.

TABLE XXII

Properties of Alloyed Chilled Iron

	High Carbon	Low Carbon
Brinell on chilled surface	650–700	575–650
Tensile strength of grey core	30,000 p. s. i.	40,000 p. s. i.
Total Carbon	3.0–3.5	2.50–3.00
Silicon	.50–1.0	.50–1.0
Nickel	4.25–4.75	4.25–4.75
Chromium	1.40–1.80	1.40–1.80

The Ni-Hard type of alloy cast iron attains Brinell hardness values on the chilled face of from 500 to more than 750. At the same time strength and toughness are increased greatly, so that it is a very useful material for resistance to wear and abrasion. Up to a hardness of about 500 Brinell the alloy can be machined with carboloy tools. There are certain places in refinery operation where this material would be useful, for example in pumps handling clay, fuller's earth suspensions, gritty oil, such as sludge-coke mixtures or gritty water and in tube cleaners.

Acknowledgement is due my associates, Messrs. T. J. Wood and F. B. Coyle for much of the data and some of the diagrams. In addition, the data and assistance contributed by various members of the petroleum industry, who felt their contributions inadequate to warrant specific mention, is gratefully acknowledged.

APPENDIX

Typical Conditions

Typical Applications of Ni and Cr in Cast Iron

	TC	Mn	Si	Ni	Cr	TS† 1000 Lbs.	BHN	Percent Steel in Charge*
Grate Bars; Stoker Parts	3.30	0.60	1.50	1.50	0.60	36	210	15–30
Light Cams	3.10	0.55	1.50	1.25	0.30	35	200	20–30
Heavy Cams	3.10	0.60	1.50	2.00	0.60	42	200	50–80
Air Cooled Cylinders	3.30	0.60	2.35	2.00	0.20	28	200	0–15
Automotive Light Cylinders	3.30	0.55	2.10	0.75	0.30	36	200	15–25
Heavy Automotive Cylinders	3.30	0.65	1.85	1.75	0.50	36	220	20–35
Light Compressor Cylinders	3.30	0.55	2.10	1.25	0.45	36	210	15–20
Light Diesel Cylinders	3.30	0.65	1.85	1.75	0.50	36	220	20–35
Light Brake Drums	3.30	0.65	2.10	1.50	0.40	35	220	15–25
Heavy Brake Drums	3.10	0.80	1.80	2.25	0.50	38	220	15–25
Clutch and Hoist Drums	3.00	0.85	1.10	1.25	0.30	40	220	30–70
Cylinder Heads	3.30	0.55	2.10	1.25	0.45	38	220	15–20
Light Cylinder Liners	3.25	0.55	2.00	1.75	0.50	36	220	20–40
Exhaust Manifolds	3.50	0.65	1.80	2.00	0.75	36	200	0–20(C)
Clutch Plates	3.30	0.65	2.10	1.50	0.40	35	220	15–25
Caustic Pots	3.30	0.50	0.70	1.50	0.60	38	230	30–50
Lead, Zinc Aluminum Pots	3.30	0.65	1.00	2.00	0.75	40	230	20–50

*A wide range in steel content has been given since the exact amount required to obtain the recommended TC content will depend on the characteristics of the individual furnace in which the material is produced. The extremes given have, however, been successfully used, and the foundryman can determine the exact amount with a knowledge of melting conditions in his own unit.

†In Arbitration Bar Section.

Heat Treatments

(C) Anneal at 1400° F.

Application of High Test Alloy Cast Iron

Casting	Percent Steel in Charge	Total Carbon	Silicon	Nickel	Chromium
Brake Drums	60	2.90–3.10	1.40	2.00	None
Cams	60	3.10	1.10	0.90	0.30
Cylinders:					
Air ammonia and CO_2	60–70	2.80–3.00	1.10	1.00–1.50	None
Hydraulic Compressor	50–60	.....	1.00	1.00	None
Printing press	50–60	.....	1.00	1.00	None
Steam	60	2.75–3.15	0.90–1.10	1.00–1.25	None
Diesel Engine:					
Liners and heads:					
Medium	60	2.90–3.10	1.00–1.20	1.50	None
Heavy	60	3.00	0.90–1.00	2.00	0.50
Gears:					
Medium and heavy	50	.....	0.80–1.00	2.00	0.60
Medium and heavy	75	.....	1.00–1.20	1.25	None
Plungers—Hydraulic Press	50–60	.....	1.00	1.00	None
Pumps:					
Medium and heavy	50	3.00–3.15	1.20	0.75–1.00	None
Medium and light	80	2.75–3.00	2.00–2.25	1.50–2.00	None
Valve Bodies	50	3.05–3.15	0.90–1.00	1.50	None
Valve bodies	60	3.00–3.15	1.25–1.50	0.75–2.50	None
Valve bodies, extra strong	70–80	2.75–3.00	1.25–2.25	1.50–2.00	None

Design of Fractionating Columns

(ARTICLE 2)

Application to Commercial Gasoline Stabilizer Test Data

PART II

GEORGE GRANGER BROWN, MOTT SOUDERS, Jr., H. V. NYLAND[a] and Wm. HESLER[b]
University of Michigan, Ann Arbor, Mich.

The greatest difficulty in attempting to check theoretical methods for the calculation of the number of plates required in a fractionating column, against actual operating data, is that of obtaining sufficiently complete and reliable data on the commercial plant.

Test Data.

The test data used in this comparison include not only the essential data for heat and material balances, but also the complete analysis of the liquid samples as withdrawn from 17 of the 48 working plates. Although the column contains 50 plates, the reflux was introduced during this test on the third actual plate which is therefore identified as plate one throughout this discussion, because the two dry plates above were not in use. Figure 8 is a simplified flow diagram of the gasoline stabilizer, with the quantity of all significant streams indicated. Table II gives the composition of feed, bottoms, distillate, reflux, side-cut and liquid on various plates with the corresponding temperatures.

In all cases, except at the extreme top and bottom of the column the composition of the vapor rising from a particular plate, as determined by heat and material balance over a section of the column, is substantially the same as that computed from equilibrium data and the composition of the liquid overflowing from that plate. Therefore the plate efficiency in this column under these conditions of operation is close to 100 percent. In other words each actual plate is about as effective as an equilibrium plate.

The ratio of liquid overflow to vapor rising in the column (L/V) as calculated for various parts of the column is given in Table II and is practically constant in the stripping section (plates 34 to 48) and in the rectifying section below the side-stream (plate 7 through 32), with the exception of the difference immediately above and below the feed plate. Above the

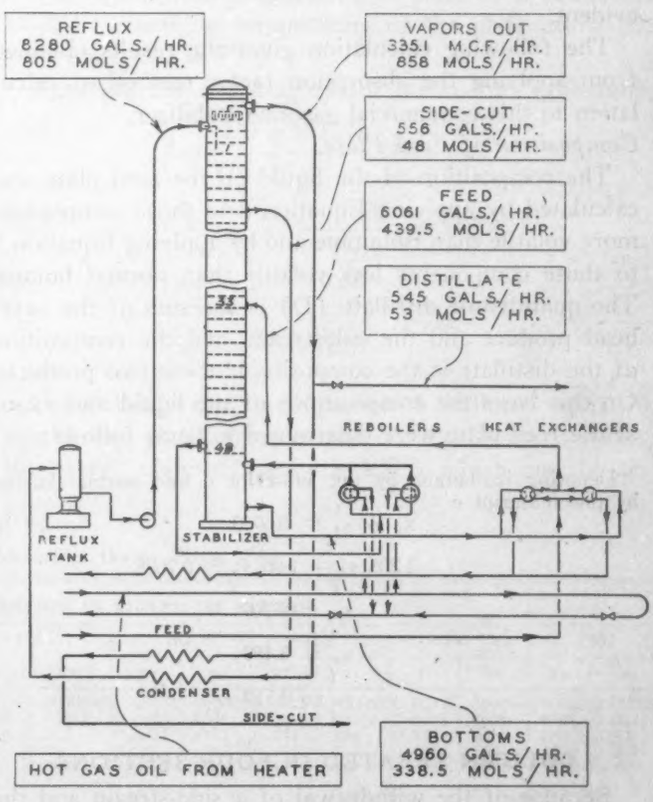


FIGURE 8
Flow Diagram of Column

(a) Present address: Sinclair Oil Refining Company, East Chicago, Indiana.
(b) Present address: Parsons Eng. Co., Mt. Vernon, Ohio.
*Nomenclature for all equations given at end of article.

TABLE II
Test Data on Commercial Gasoline Stabilizer

	Feed	Bottoms	Distillate	Reflux	Distillate plus side cut	Trays Below Feed 46	44	42	40	36
CH_4 (mol fraction)	0.0029		0.0258		0.0135					
C_2H_6	0.0382		0.1335		0.0732					
C_3H_8	0.1226		0.782		0.5875			0.0014	0.0052	.0239
iso—C_4H_{10}	0.0798	0.0347	0.0527		0.2900	.0907	.0874	0.0966	0.1489	.1577
n—C_4H_{10}	0.2752	0.3295	0.0035		0.0357	.5731	.6311	0.662	0.5867	.5452
iso—C_5H_{12}	0.103	0.1303	0.0025(?)			.1051	.0944	0.0743	0.078	.0699
n—C_5H_{12}	0.0929	0.1125				.0821	.0631	0.0277	0.0573	.0611
C_7H_{16}	0.2854	0.393				.149	.124	0.138	0.1239	.1422
Reflux Ratio $\left(\frac{L}{D}\right)$										
$\left(\frac{L}{V}\right)$						1.32		1.325		1.33
Quantity (mols/hr.)	439.5	338.5	53	805	101					
Temperature (°F.)	255	330	130	72		278	272	268	266	262
Trays								15		

TRAYS ABOVE FEED

	32	30	24	22	20	16	14	12	10	Side-cut 6	4	2
CH_4 (mol fraction)											0.0180	0.0184
C_2H_6	.0054	.009	.0022	.0012	.0029	.0032	.0021	.0016	0.0033	0.0033	0.0243	0.1053
C_3H_8	.0902	.0839	.0897	.0898	.0905	.0889	.1026	.0857	0.1204	0.3697	0.780	0.8085
iso—C_4H_{10}	.195	.2514	.264	.3042	.3586	.4365	.4794	.5408	0.5896	0.5524	0.1774	0.0638
n—C_4H_{10}	.5744	.6192	.6403	.6036	.5449	.4694	.4124	.3688	0.287	0.0713	0.0165	0.004
iso—C_5H_{12}	.0536	.0214	.0038	.0012	.0031	.002	.0035	.0031		0.0053		
n—C_5H_{12}	.0375	.0106										
C_7H_{16}	.0439	.0045										
Reflux Ratio $\left(\frac{L}{D}\right)$	8.06	9.35	9.45	9.45	9.45	.945	9.45	9.45	9.45		19.2	16.6
$\left(\frac{L}{V}\right)$	.89	.903	.905	.905	.905	.905	9.05	.905	0.905		0.95	0.943
Quantity (mols/hr.)												
Temperature (°F.)	235	225	221	220	219	217	216	213	209	184	161	116
Trays					32							

side-cut the disturbing effect of the cold reflux is clearly evident.

The following calculation gives the results obtained from applying the absorption factor method of calculation to this commercial gasoline stabilizer.

Composition of Feed Plate.

The composition of the liquid on the feed plate was calculated by applying Equation 8 to those components more volatile than isobutane and by applying Equation 9 to those components less volatile than normal butane. The quantity of distillate (D) is the sum of the overhead product and the sidestream, and the composition of the distillate is the composite of these two products. On this basis the compositions of the liquid and vapor at the feed plate were determined to be as follows:

Denoting iso-butane by the subscript d and normal butane by the subscript e

$$x_{d_f} + x_{e_f} = 0.6963$$

$$1.205\ x_{d_f} + 1.06\ x_{e_f} = 0.7688$$

$$x_{d_f} = 0.207$$

$$x_{e_f} = 0.489$$

$$y_{e_f} = 0.519$$

COLUMN TREATED IN FOUR SECTIONS

Because of the withdrawal of a side-stream and the effect of vaporization in the reboiler, the column should be divided into four sections; (1) the top six working plates above the side-stream, (2) the section between the feed plate and the side-stream, (3) the section between the feed and lowest plate for which analytical data are available, and (4) the remainder including the reboiler.

The Section Above Plate 7

This section is operating as an absorber of n-butane. The mole fraction of n-butane in the vapor rising into this section is obtained from a material balance around the top of the column including plate 6 which is the plate from which the side stream is withdrawn.

$$y_{e_7} = 0.905 \times 0.0713 + 0.0956 \times 0.0357 = 0.0649$$

The equilibrium temperature of plate 6 as computed from the composition of the liquid is 190°F. and the equilibrium temperature of the top plate as computed from the vapor composition is 133°F.

Applying the absorption factor method to n-butane above the side stream.

$$K_A = \frac{0.72 + 0.41}{2} = 0.565$$

$$A = \frac{L}{K_A V} = \frac{0.95}{0.565} = 1.68$$

$$\frac{y_7 - y_1}{y_7 - K_1 x_R} = \frac{y_7 - y_1}{y_7 - K_1 y_1} = \frac{0.0649 - 0.0035}{0.0649 - 0.41 \times 0.0035} = 0.967$$

Using this value in Equation 5 indicates that 5 equilibrium plates are required in this section of the column. Although there are 8 actual plates in this section, two of them were dry and there were only 6 working plates during this test as indicated in Figure 8. The indicated overall plate efficiency in this section based on n-butane is therefore 83%.

Plate to plate calculations working down from plate 1 and using all components in the overhead vapors as summarized in Table III indicates 6.5 equilibrium plates on the basis of propane, 8.2 plates for iso-butane and 4.8 plates for n-butane. The average for all three components is 6.5 equilibrium plates, which is the same as indicated for propane, or an average overall plate ef-

TABLE III
Composition at Feed Plate—Temperature 256°F.

	x_f	K 300 lbs./sq. in. abs. 256°F.	y_f
CH_4	.00015	9.6	.00142
C_2H_6	.00305	3.18	.00979
C_3H_8	.0649	1.78	.1157
iso-C_5H_{12}	.0698	.717	.0501
n-C_5H_{12}	.0529	.63	.03235
C_7H_{16}	.1129	.193	.0218
	0.3037		0.2312

ficiency of 108%. An error in the analysis of the overhead gas from the column in reporting 0.23% as n-butane instead of iso-butane would account for the apparent discrepancy in number of equilibrium plates as computed for iso and normal butane. Since the separation of iso and normal butane in the analysis of such a product is difficult and might easily incorporate this error, the actual plate efficiency in this section of the column is probably nearer 108% than 83%. In any case the result obtained by the absorption factor method agrees with that indicated by plate to plate computations when compared on the basis of the same component.

The Section Between Feed Plate and Plate 6

This section is operating as an absorber of n-butane. Assuming a linear temperature distribution, the equilibrium temperature of the plate above the feed plate is calculated as 254°F. The equilibrium temperature of plate 7 is 193°F.

Applying the absorption factor method to n-butane,

$$K_A = \frac{1.05 + 0.73}{2} = 0.89$$

$$A = \frac{L}{K_A V} = \frac{0.905}{0.89} = 1.017$$

$$\frac{y_f - y_7}{y_f - K_7 x_6} = \frac{0.5190 - 0.0649}{0.5190 - 0.0520} = 0.9724$$

Using this value in Equation 5 indicates that 28 equilibrium plates are required. Since there are 26 plates in this section, the overall plate efficiency is 108%.

Because the vapor formed in the feed heater is more volatile than that in equilibrium with the liquid leaving the feed plate, the total vapor rising to the plate above is actually more volatile than the equilibrium vapor calculated for use with the absorption factor method. This results in actual temperatures lower than the calculated temperature for plates immediately above the feed, and a corresponding adjustment of the composition which may account for the concentration of n-butane in the actual column having a maximum value above the feed plate. If this maximum in the composition of n-butane were significant, the number of equilibrium plates computed on the basis of n-butane would be too low, and the indicated plate efficiency would be too small. The following application of the absorption factor to iso-pentane over that section of the column (plates 32 to 23, inclusive) which includes the maximum concentration of n-butane (plate 26) indicates a plate efficiency of 100% which verifies the calculation based on n-butane (108% plate efficiency.)

Using liquid composition for plate 22, a material balance around the top of the column including plate 22 gives the concentration of iso-pentane in vapor rising from plate 23

$y_{23} = 0.905 \times 0.0012 = .00109$
$t_{23} = 221°F.$ $K_{23} = 0.56$
$t_{23} = 254°F.$ $K_{23} = 0.71$

Average $K_A = 0.635$

$$A = \frac{0.905}{0.635} = 1.425$$

$$\frac{y_f - y_{23}}{y_f - K_{23} x_{22}} = \frac{0.0501 - 0.00109}{0.0501 - 0.56 \times 0.0012} = 0.9915$$

Using this value in equation 5 (Figure 7) indicates 10 equilibrium plates as compared with 10 actual plates or an overall plate efficiency of 100%. Since the same result (within the accuracy of iso-pentane concentration on plate 22) is obtained by application of the absorption factor to iso-pentane as to n-butane, a correct solution has been obtained.

The Section Between Feed Plate and Plate 47

This section is operating as a stripper of iso-butane. The mole fraction of iso-butane in the vapor entering this section (y_{d}) is obtained from a material balance around the bottom product and between plates 46 and 47;

$$y_{d} = 1.325 \times 0.0907 - 0.325 \times 0.0347 = 0.1089$$

The equilibrium temperature of plate 46 is calculated as 283°F., and the temperature of the plate below the feed plate as 258°F.

Applying the stripping factor method to iso-butane,

$$K_S = \frac{1.34 + 1.23}{2} = 1.285$$

$$S = \frac{K_S \overline{V}}{\overline{L}} = \frac{1.285}{1.325} = 0.970$$

$$\frac{x_f - x_{46}}{x_f - \frac{y_{47}}{K_{46}}} = \frac{0.207 - 0.0907}{0.207 - \frac{0.1089}{1.34}} = 0.924$$

Using this value in Equation 6 indicates that 14 equilibrium plates are required. With 13 actual plates, the overall plate efficiency is 108% which may be ac-

TABLE IV
Summary of Step-wise Calculation Down from Top

	MOL FRACTION IN LIQUID OR VAPOR																	
	133		146		155		163		172		182		188		197		202	
Temp. (°F.)	Y_1	x_1	y_2	x_2	y_3	x_3	y_4	x_4	y_5	x_5	y_6	x_6	y_7	x_7	y_8	x_8	y_9	x_9
CH_4	0.0258	0.0021	0.00345	0.00026	0.0017	0.00012	0.00158	0.0001	0.00156	0.0000945	0.00154	.000087	0.0013	0.000067	0.00128	.000064	.00127	0.000058
C_2H_6	0.1335	0.069	0.0726	0.0356	0.0412	0.0195	0.026	0.0119	0.0188	0.00835	0.0155	.0066	0.0125	0.00515	0.0111	.0044	.0105	0.0041
C_3H_8	0.782	0.822	0.8196	0.788	0.7876	0.716	0.7196	0.623	0.6326	0.518	0.5331	.4185	0.434	0.324	0.348	.252	.283	0.20
iso—C_4H_{10}	0.0527	0.099	0.0964	0.1593	0.1533	0.232	0.2219	0.311	0.296	0.39	0.371	.4555	0.4412	0.515	0.4952	.55	.5272	0.569
n—C_4H_{10}	0.0035	0.0085	0.0082	0.0175	0.0167	0.0321	0.0305	0.054	0.0511	0.0837	0.0792	.119	0.1114	0.156	0.1446	.1926	.1779	0.227
iso—C_5H_{12}																		
n—C_5H_{12}																		
C_7H_{16}																		
Total	0.9975	1.000	1.000	1.000	1.000	0.999	0.999	1.000	1.000	1.000	1.000	.999	1.000	1.000	1.000	.999	.999	1.000

cepted without further checking since the iso-butane shows no indication of a maximum concentration in this section.

Checking the assumed temperature of the feed plate (256°F.) by the linear temperature equation

$$t_f = 193 + \frac{28}{42}(283 - 193) = 193 + 60 = 253°F.$$

The Section Below Plate 46

This section includes the reboiler and operates as a stripper of iso-butane. The calculated equilibrium temperature at the reboiler is 350°F. and at plate 47 is 300°F.

Applying the stripping factor to iso-butane,

$$K_B = \frac{1.67 + 1.42}{2} = 1.545$$

$$S = \frac{K\overline{V}}{\overline{L}} = \frac{1.545}{1.325} = 1.166$$

$$\frac{x_{46} - x_m}{x_{46} - \frac{y_{m+1}}{K_m}} = \frac{x_{46} - x_B}{x_{46} - \frac{x_B}{K_B}} = \frac{0.0907 - 0.0347}{0.0907 - \frac{0.0347}{1.67}} = 0.801$$

Using this value in Equation 6 indicates that three equilibrium plates are required. There are two actual plates plus the reboiler which should be considered as one plate, making a total of three plates, and the indicated overall plate efficiency of this part of the column is 100 percent.

Plate Efficiency

The overall plate efficiencies of from 100 to 108 percent here observed may be misinterpreted if the concept of plate efficiency is not clearly defined. In general plate efficiency may be defined as the ratio of the performance of an actual plate to the performance of some standard plate. The standard plate here employed is the "equilibrium plate" so defined that all the vapor rising from a plate after contacting the liquid thereon has an average composition that is in equilibrium with the liquid overflowing to the plate below. Such an equilibrium plate assumes a single equilibrium contact per plate.

Plates in an actual column, however, usually involve a number of successive contacts per plate. The liquid changes composition progressively as it flows across the plate, so that the vapor flowing through each successive row of caps approaches equilibrium with a liquid of different composition. Even if equilibrium were obtained at each contact, the average composition of the vapor leaving the plate would be considerably different from the composition of the vapor in equilibrium with the liquid overflowing from the plate.

It may be demonstrated that the successive contact plate upon which equilibrium is attained at each contact produces a greater change in the composition of the vapor passing through it (i.e., is more "efficient" under ideal conditions) than does the standard equilibrium plate which involves only a single equilibrium contact.

There is no inconsistency either in theory or practice in an actual column developing plate efficiencies equal to or greater than 100 percent.

A Method for Design

In the design of a column the compositions on various plates are not available and there may be a temptation to assume a linear temperature gradient throughout the rectifying and stripping columns. Although this was approximately true in the theoretical columns computed in Table I as given in Figures 1-6, it is not a valid assumption in all cases. In the actual column under consideration this assumption leads to the following results:

Rectifying Column Treated as an Absorber of n-Butane

Top temperature	133°F.	$K = 0.41$
Plate f − 1 temperature	254°F.	$K = 1.05$
	Average	$K_A = 0.73$

$$A = \frac{L}{K_A V} = \frac{0.905}{0.73} = 1.24$$

$$\frac{y_f - y_1}{y_f - K_1 y_1} = \frac{0.5190 - 0.0035}{0.5190 - 0.41 \times 0.0035} = 0.996$$

These values in Equation 5 indicate 18 equilibrium plates in this section which includes 32 actual plates or an apparent overall efficiency of 56.3 percent.

Stripping Section as Stripper of Iso-Butane

Bottom Temperature	350°F.	$K = 1.67$
Plate f + 1 temperature	258°F.	$K = 1.28$
	Average	$K_A = 1.45$

$$S = \frac{K_A V}{L} = \frac{1.45}{1.325} = 1.0943$$

$$\frac{x_f - x_B}{x_f - \frac{x_B}{K_B}} = \frac{0.207 - 0.0347}{0.207 - \frac{0.0347}{1.67}} = 0.9254$$

These values in equation 6 indicate 8 equilibrium plates in this section as compared with 16 actual plates or an apparent overall plate efficiency of 50 percent. Attempted check of the feed plate temperature which was assumed to be 256°F. is:

$$t_f = 133° + \frac{18}{26}(350 - 133) = 283°F.$$

This indicates clearly that any solution obtained for this column based on an assumed linear temperature gradient throughout will be in error as the feed plate temperature has been correctly determined to be close to 256°F., and the plate efficiency close to 100 percent.

A SATISFACTORY PROCEDURE FOR DESIGN

By combining the absorption factor method with the plate to plate calculation at the extremities satisfactory results may be obtained without the laborious procedure of the stepwise calculation. For design purposes this method includes the following steps:

1. Fix the distribution of the cut components, from the known feed, in overhead and bottoms.
2. Estimate the composition of overhead and bottoms on the basis of a material balance putting all components more volatile than cut components in overhead and all less volatile in bottoms.

3. Determine "reflux ratio" or $\frac{L}{V}$ by a heat balance or if heat input has not been fixed, assume value of $\frac{L}{V}$.

4. Determine equilibrium temperatures for top plate and for bottom plate based on estimated compositions of tops and bottoms and operating pressure using methods previously described.[2]

5. Compute equilibrium compositions and temperatures on successive plates down from top and up from bottom[4] until the temperature difference between successive plates is constant, in order to determine composition and temperature of the top and bottom terminal plates.

6. Estimate feed plate temperature and composition as described herein.

7. Apply absorption factor method to less volatile components in rectifying column, and stripping factor to more volatile components in stripping column, between the terminal plates and feed plate in the manner described, checking the assumed feed plate temperature on the basis of a linear temperature gradient between the terminal plates and with the precautions mentioned.

Caution.

The values for the equilibrium constants of the individual hydrocarbons[6] are intended for use in equilibrium calculations between the liquid and vapor phase, only at pressures and temperatures considerably below the critical pressure or temperature of the mixture. This fact must be kept in mind when using these values in the design of fractionating columns as the numerical values of the equilibrium constant K of all components equals unity at the critical point of the mixture.[2] In determining the pressure or temperature at which a fractionating column is to be operated, it is absolutely essential to choose temperatures and pressures below the critical of the material existing in the column. At pressures or temperatures above the critical, the material can exist in only one phase and there can be no equilibrium between two phases, and no functioning of the column. The equilibrium constant gives no information as to the critical temperature or pressure of the components or mixtures. This information must be obtained from other sources and given due consideration, in studying the operating conditions in the design of fractionators.

ACKNOWLEDGMENT

The plant data used in this paper were kindly furnished by the Development Department of the Union Oil Company, California, through Mr. E. G. Ragatz. Without these data complete demonstration of the application of the absorption factor method to commercial plant practice would have been impossible.

CONCLUSIONS

From the comparison of actual plant test data with the computed results obtained by the application of the absorption factor method to the calculation of this gasoline stabilizer it appears:

(1) That the absorption factor method offers a simple and reliable method for computing the number of equilibrium plates required in commercial gasoline stabilizers, and probably other similar equipment in which the equilibrium conditions between liquid and vapor may be assumed to follow the relationships of ideal solutions.

(2) That the overall plate efficiency of natural gasoline stabilizers, at least of this type of construction and operating at a pressure of about 300 pounds absolute, is approximately 100 percent.

LITERATURE CITED

[1] Brown, Souders and Nyland, Ind. Eng. Chem., 24, 522 (1932).
[2] Katz and Brown, Ind. Eng. Chem., 25, 1373 (1933).
[3] Kremser, Natl. Petroleum News, p. 43, (May 21, 1930), and Refiner, Vol. 9, No. 6, June, 1930, p. 144.
[4] Lewis and Matheson, Ind. Eng. Shem., 24, 494 (1932).
[5] Souders and Brown, Ind. Eng. Chem., 24, 519 (1932).
[6] Souders, Selheimer and Brown, Ind. Eng. Chem., 24, 517 (1932).
[7] Underwood, A. J. V., Trans. Inst. Chem. Eng. (London), 10, 112. (1932).

SUMMARY

A simplified method of computing the number of equilibrium plates required for the separation of complex mixtures, has been developed and found reliable as compared with theoretically rigorous calculations and with test data on commercial equipment. The overall plate efficiency of a natural gasoline fractionator was found to be close to 100 percent.

NOMENCLATURE

F = Moles of feed to column; used as subscript to signify feed.
B = Moles of bottom product; used as subscript to signify bottom product.
D = Moles of distillate withdrawn as overhead product; used as subscript to signify overhead product.
V = Moles of vapor rising from plate in rectifying section; used as subscript to signify vapor phase.
L = Moles of liquid overflowing from plate in rectifying section; used as subscript to signify liquid phase.
$\overline{V}$ = Moles of vapor rising from plate in stripping section.
$\overline{L}$ = Moles of liquid overflowing from plate in stripping section.
a, b, c, d, etc., refer to moles of individual components of which a is the most volatile; when used as subscript the letters refer to individual components.
x = Mole fraction of any component in the liquid.
y = Mole fraction of any component in the vapor.
n = Number of theoretical plates above feed plates; used as subscript, refers to any plate in rectifying section.
m = Number of theoretical plates below feed plate; used as subscript, refers to any plate in stripping section.
f = Feed plate, i.e., plate from which the vapor rising becomes the feed to the rectifying section and liquid overflowing becomes the feed to the stripping section.
1, 2, 3, etc., refer to the first, second, third, etc., plate of the column, numbering from the top downward.
K = Equilibrium constant for a particular component.
$A = L/KV$ = absorption factor for a particular component
$S = \frac{K\overline{V}}{\overline{L}}$ = stripping factor for a particular component.

Physical and Thermodynamic *Properties of* Methane and Ethane

I. N. BEALL

FROM time to time the writer has discussed the various physical and thermodynamic properties of the light hydrocarbons of natural gas. In answer to many inquiries as to more detailed and extensive information on this apparently interesting subject the following tables have been developed and compiled as a means of ready reference. In the two tables given, the physical and thermodynamic data for methane and ethane have been compiled in convenient form similar to that used in steam tables. All of the values are given in the English system, that is degrees Fahrenheit and degrees absolute (Rankine) = 460 + °F., specific volumes in cubic feet per pound, specific density in pound per cubic foot and heat quantity as B.t.u. Anyone familiar with the use of steam tables should have no difficulty in the use of these tables.

In addition to a rather extensive search of the literature it has been necessary to sift, correlate and extend the data to conform to consecutive order of tabulation requirements. The most dependable data at present available has been used throughout. Engineers may use these tables and be well within the limits required for design and operating calculation.

In order to further increase the value of this work as reference the equivalent values of electrical, mechanical and heat units are included. The writer will welcome any criticism as to the practicability and accuracy of the tables to the end that better engineering data may be evolved for the future use by the industry. In subsequent articles tables will be given for propane, isobutane, butane pentanes, etc., of the homologous series. Methods for using the tables will also be discussed.

SUBSEQUENT to publication of Mr. Beall's article in February, "Some Thermodynamic Data of Application to the Light Saturated Hydrocarbons," much interest was evidenced in the subject, and additional and more extensive information was requested. In response to this interest Mr. Beall consented to undertake the tedious task of preparing the accompanying discussion and highly important tabular data, for publication in THE REFINER, where it appears for the first time.

Mr. Beall has contributed a large number of highly important articles during the past three or four years, presenting therein technical information concerning which THE REFINER and the author have received many commendatory letters. In regard to the present work the author requests criticism and suggestions as to the practicability of the tables and accuracy of the information to the end that better engineering information may be evolved for the use of the industry. Any such opinions directed to THE REFINER will be promptly forwarded to Mr. Beall and if further work of this nature seems desirable he will undertake its preparation.

CALCULATING VAPOR PRESSURE OF MIXTURES

The approximate vapor pressure of a. mixture of methane and ethane may be calculated as follows:

Assumptions:

$X_2 = 0.6$ mol fraction of ethane
$X_1 = 0.4$ mol fraction of methane
Temp $= -128°$ F. $= 332°$ Abs.
Vapor Pressure Methane at $-128°$ F $= 576.6 = P_1$
Vapor Pressure Ethane at $-128°$ F. $14.80 = P_2$
$x_1 P_1 + x_2 P_2 = 0.4\ (576.6) + 0.6\ (14.80) = 239.5$

In a similar manner the boiling temperature of a definite mixture may be calculated for an established pressure as for example at 45 lbs. absolute = 30 lb. ga. approximately.

Temp. of Ethane at 45 lbs. Abs. = 370° F.
Temp. of Methane at 45 lbs. Abs. = 228° F.
0.6 (370) + 0.4 (228) = 313.2° Abs. = 146.8° F.

HEAT REQUIRED FOR VAPORIZATION

In vaporizing a liquid the liquid has to be heated up to the boilng point after which no further temperature rise occurs, the heat then being consumed in changing the substance from the liquid to the vapor state. As illustration refer to Table II. How much heat would be required to evaporate 35 lbs. of liquid ethane Temp. = — 120° F., pressure of vaporization 51.5 lbs. Abs., under the heat content of liquid at — 120° F = 4.7 B.t.u. at 51.5° Abs. Corresponding to 80° F. the heat content is 28.7. The difference 28.7 — 4.7 = 24.0, B.t.u. would then be the amount of heat required to raise the temperature of the liquid from — 120° F. to — 80° F. and 31.8 lbs. Ga, the latent heat of vaporization L = 188.4 B. t u. The total heat input would therefore be 188.4 + 4 + 24.0 = 212.4 B.t.u.

LIQUID VOLUME

As the temperature rises the liquid volume increases, and the vapor volume decreases per unit weight. For

TABLE I
Methane

Temperature		Pressure, Lb./In.²		Volume		Density		Heat Content Above −280° F. Btu/Lb.					Entropy.	
t ° F.	T Abs.	Gauge	Abs.	v Liquid Ft.³ /Lb.	V Vapor Ft.³ /Lb.	1/v Liquid Lb./ Ft.³	1/V Vapor Lb./ Ft.³	h Liquid	L Latent	H⁵⁰ Vapor	H Vapor	s Liquid	S Vapor
−280	180	−10.3	4.4	.0364	.....	27.5	.....	0.0	229.4	114.7	229.4	.000	1.2750
−278	182	− 9.6	5.1	.0365	.....	27.4	.....	1.7	228.6	115.9	230.3	.009	1.266
−276	184	− 8.9	5.8	.0366	.....	27.3	.....	3.3	227.8	117.1	231.1	.018	1.256
−274	186	− 8.3	6.4	.0368	.....	27.2	.....	4.9	226.9	118.4	231.8	.026	1.247
−272	188	− 7.5	7.2	.0369	.....	27.1	.....	6.6	226.1	119.6	232.7	.035	1.238
−270	190	− 6.7	8.0	.0370	.....	27.0	.....	8.2	225.3	120.8	233.5	.043	1.229
−268	192	− 5.5	9.2	.0372	.....	26.9	.....	9.9	224.5	122.1	234.4	.051	1.221
−266	194	− 4.5	10.2	.0373	.....	26.8	.....	11.5	223.7	123.3	235.2	.058	1.2129
−264	196	− 3.3	11.4	.0375	.....	26.7	.....	13.1	222.9	124.6	236.0	.066	1.2047
−262	198	− 1.8	12.9	.0376	.....	26.6	.....	14.8	222.1	125.8	236.9	.074	1.1966
−260	200	0.0	14.7	.0377	8.9047	26.5	.1123	16.4	221.3	127.0	237.7	.077	1.1885
−258	202	.9	15.6	.0379	8.4756	26.4	.118	18.1	220.4	128.3	238.5	.079	1.1812
−256	204	2.4	17.1	.0380	7.6923	26.3	.130	19.8	219.6	129.6	239.4	.081	1.1738
−254	206	4.4	19.1	.0382	7.0422	26.2	.142	21.4	218.8	130.8	240.2	.084	1.1660
−252	208	6.4	21.1	.0383	6.4103	26.1	.156	23.0	218.0	132.1	241.0	.110	1.1590
−250	210	8.4	23.1	.0385	5.9172	26.0	.169	24.7	217.2	133.4	241.9	.117	1.152
−248	212	10.4	25.1	.0386	5.4945	25.9	.182	26.4	216.3	134.6	242.7	.124	1.1450
−246	214	12.4	27.1	.0388	5.1282	25.8	.195	28.1	215.5	135.9	243.6	.131	1.1390
−244	216	14.4	29.1	.0389	4.8077	25.7	.208	29.8	214.7	137.1	244.5	.138	1.1132
−242	218	16.4	31.1	.0391	4.5249	25.6	.221	31.5	213.9	138.4	245.4	145	1.126
−240	220	18.4	33.1	.0392	4.2735	25.5	.234	33.2	213.0	139.7	246.2	.151	1.1191
−238	222	20.7	35.4	.0394	4.0160	25.4	.249	34.9	212.2	141.0	247.1	.157	1.113
−236	224	23.9	38.6	.0395	4.7174	25.3	.269	36.7	211.3	142.3	248.0	.163	1.107
−234	226	27.1	41.8	.0397	3.4602	25.2	.289	38.4	210.5	143.5	248.9	.170	1.1073
−232	228	30.3	45.0	.0400	3.2258	25.0	.310	40.1	209.6	144.8	249.7	.176	1 095
−230	230	33.4	48.1	.0402	3.0303	24.9	.330	41.8	208.7	146.1	250.5	.182	1.0891
−228	232	36.6	51.3	.0403	2.8571	24.8	.350	43.5	207.8	147.3	251.3	.188	1.083
−226	234	39.7	54.4	.0405	2.7027	24.7	.370	45.3	206.9	148.6	252.2	.194	1.077
−224	236	42.9	57.6	.0407	2.5575	24.6	.391	47.0	206.0	149.9	253.0	.200	1.072
−222	238	46.1	60.8	.0408	2.4330	24.5	.411	48.8	205.0	151.2	253.8	.205	1.066
−220	240	49.8	64.5	.0410	2.2988	24.4	.435	50.5	204.0	152.5	254.5	.211	1.0604
−218	242	55.0	69.7	.0412	2.1598	24.3	.463	52.3	203.0	153.8	255.3	.216	1.055
−216	244	60.0	74.7	.0413	2.0284	24.2	.493	54.1	202.0	155.0	256.1	.222	1.050
−214	246	65.1	79.8	.0417	1.9084	24.0	.524	55.9	201.0	156.3	256.9	.227	1.044
−212	248	70.2	84.9	.0418	1.8050	23.9	.554	57.7	200.0	157.6	257.7	.232	1.039
−210	250	75.2	89.9	.0420	1.7094	23.8	.585	59.5	199.0	158.9	258.5	.238	1 0340
−208	252	80.3	95.0	.0422	1.6260	23.7	.615	61.3	197.9	160.2	259.2	.243	1.029
−206	254	86.3	101.0	.0424	1.5504	23.6	.645	63.1	196.8	161.4	259.9	.248	1.023
−204	256	91.4	106.1	.0426	1.4815	23.5	.675	64.9	195.6	162.7	260.5	.253	1.018
−202	258	99.3	114.0	.0427	1.4205	23.4	.704	66.7	194.5	163 9	261.2	.258	1.012
−200	260	106.1	120.8	.0431	1.3369	23.2	.748	68.5	193.4	165.2	261.9	.264	1.0073
−198	262	113.1	127.8	.0433	1.2594	23.1	.794	70.4	192.2	166.4	262.6	.269	1.002
−196	264	120.1	134.8	.0437	1.1933	22.9	.838	72.3	190.9	167.7	263.2	.274	.997
−194	266	126.8	141.5	.0439	1.1312	22.8	.884	74.4	189.6	169.0	263.8	.279	.992
−192	268	133.8	148.5	.0441	1.0776	22.7	.928	76.1	188.4	170.2	264.5	.284	.987
−190	270	140.7	155.4	.0444	1.0256	22.5	.975	78.0	187.1	171.5	265.1	.289	.982
−188	272	147.7	162.4	.0446	0.9804	22.4	1.020	80.0	185.6	172.8	265.6	.294	.977
−186	274	154.6	169.3	.0450	0.9346	22.2	1.074	81.9	184.1	174.0	266.0	.298	.971
−184	276	165.1	179.8	.0455	0.9009	22.0	1.110	83.8	182.7	175.2	266.5	.303	.966
−182	278	174.3	189.0	.0457	0.8547	21.9	1.17	85.7	181.2	176.4	266.9	.308	.961
−180	280	183.2	197.9	.0461	0.8065	21.7	1.24	87.7	179.7	177.6	267.4	.313	.955
−178	282	191.9	206.6	.0463	0.7692	21.6	1.30	89.7	178.1	178.8	267.8	.318	.950
−176	284	200.6	215.3	.0467	0.7299	21.4	1.37	91.8	176.5	180.0	268.3	.323	.944
−174	286	209.5	224.2	.0469	0.6993	21.3	1.43	93.8	174.8	181.2	268.6	.328	.939
−172	288	218.3	233.0	.0474	0.6711	21.1	1.49	95.8	173.2	182.3	269.0	.333	.933
−170	290	227.0	241.7	.0476	0.6410	21.0	1.56	97.9	171.2	183.5	269.1	.338	.928
−168	292	235.7	250.4	.0481	0.6173	20.8	1.62	100.0	169.3	184.7	269.3	.343	.922
−166	294	250.3	265.0	.0483	0.5882	20.7	1.70	102.1	167.5	185.9	269.6	.348	.917
−164	296	259.7	274.4	.0488	0.5678	20.5	1.78	104.2	165.6	187.0	269.8	.352	.911
−162	298	268.9	283.6	.0490	0.5525	20.4	1.81	106.4	163.4	188.2	270.0	.358	.906
−160	300	278.3	293.0	.0495	0.5181	20.2	1.93	108.7	161.4	189.3	270.1	.363	.900
−158	302	287.5	302.2	.0498	0.4975	20.1	2.01	110.9	159.2	190.5	270.1	.368	.894
−156	304	297.0	311.7	.0503	0.4808	19.9	2.08	113.2	157.0	191.7	270.2	.373	.888
−154	306	306.3	321.0	.0505	0.4630	19.8	2.16	115 4	154.8	192.9	270.2	.378	.882
−152	308	315.3	330.0	.0508	0.4484	19.7	2.23	117.9	152.1	194.0	270.0	.383	.876
−150	310	324.1	338.8	.0515	0.4329	19.5	2.31	120.3	149.5	195.1	269.8	.388	.870
−148	312	332.0	346.7	.0515	0.4184	19.4	2.39	122.7	146.8	196.2	269.5	.393	.863
−146	314	340.6	355.3	.0518	0.4065	19.3	2.46	125.2	144.2	197.4	269.4	.398	.856
−144	316	349.2	363.9	.0524	0.3937	19.1	2.54	127.8	141.1	198.4	268.9	.404	.850
−142	318	372.4	387.1	.0529	0.3759	18.9	2.66	130.5	137.8	199.5	268.3	.410	.843
−140	320	397.6	412.3	.0541	0.3413	18.5	2.93	133.2	134.4	200.5	267.6	.416	.836
−138	322	423.8	438.5	.0552	0.3115	18.1	3.21	136.0	131.1	201.6	267.1	.422	.826
−136	324	447.8	462.5	.0568	0.2865	17.6	3.49	138.7	127.8	202.6	266.5	.428	.817
−134	326	471.8	486.5	.0581	0.2653	17.2	3.77	141.8	122.7	203.3	264.5	.435	.808
−132	328	496.5	511.2	.0595	0.2532	16.8	3.95	145.0	117.6	204.0	262.6	.442	.799
−130	330	524.3	539.0	.0621	0.2028	16.1	4.93	148.2	112.6	204.6	260.8	.449	.790
−128	332	561.9	576.6	.0694	0.1538	14.4	6.50	151.4	107.7	205.3	259.1	.457	.780
−126	334	599.6	614.3	.0787	0.1261	12.7	7.93	157.1	96.0	205.8	253.1	.478	.758
−124	336	658.5	673.2	.0993	0.9930	10.07	10.07	164.9	76.8	206.0	241.7	.502	.719
−122	338	.....	.....	.....	.....	.....	.....	172.6	57.5	206.4	230.1	.511	.681
−120	340	.....	.....	.....	.....	.....	.....	180.4	38.0	206.7	218.4	.531	.642
−118	342	.....	.....	.....	.....	.....	.....	189.5	19.1	207.0	208.6	.543	.610
−116	343	.....	.....	.....	.....	.....	.....	206.1	0.0	207.3	206.1	.599	.599

TABLE II
Ethane

Temperature		Pressure Lb./In.²		Volume		Density		Heat Content Above −128° F.				Entropy From −128° F.	
t ° F.	T ° Abs.	p Gauge	P Abs.	v Liquid Ft.³ /Lb.	V Vapor Ft.³ /Lb.	1/v Liquid Lb. /Ft.³	1/v Vapor Lb. /Ft.³	h Liquid Btu /Lb.	L Latent Btu /Lb.	H Total Btu /Lb.		s Liquid	S Vapor
−128	332	0.10	14.80	0.02935	7.7519	34.07	.129	0.	199.5	199.5		0.0	0.601
−126	334	1.1	15.8	0.02950	7.2993	34.0	.137	1.2	199.1	200.3		0.003	0.600
−124	336	2.2	16.9	0.02965	6.8966	33.9	.145	2.4	198.7	201.1		0.006	0.599
−122	338	3.2	17.9	0.02980	6.4935	33.8	.154	3.5	198.3	201.8		0.009	0.597
−120	340	4.3	19.0	0.02997	6.1350	33.7	.163	4.7	197.9	202.6		0.011	0.596
−118	342	5.3	20.	0.03002	5.8480	33.6	.171	5.9	197.5	203.4		0.014	0.595
−116	344	6.4	21.1	0.03007	5.5556	33.5	.180	7.0	197.1	204.1		0.018	0.594
−114	346	7.4	22.1	0.03012	5.3191	33.45	.188	8.2	196.6	204.8		0.022	0.592
−112	348	8.5	23.2	0.03017	5.0761	33.35	.197	9.4	196.2	205.5		0.026	0.591
−110	350	10.0	24.7	0.03022	4.7847	33.3	.209	10.5	195.7	206.2		0.030	0.590
−108	352	11.5	26.2	0.03027	4.5249	33.2	.221	11.8	195.3	207.1		0.034	0.589
−106	354	13.0	27.7	0.03032	4.3103	33.1	.232	13.0	194.8	207.8		0.037	0.588
−104	356	14.5	29.2	0.03037	4.0984	33.0	.244	14.2	194.4	208.6		0.040	0.586
−102	358	16.0	30.7	0.03042	3.9216	32.9	.255	15.3	194.0	209.3		0.043	0.585
−100	360	17.5	32.2	0.03040	3.7453	32.8	.267	16 5	193.5	210 0		0.046	0.584
− 98	362	19.0	33.7	0.03058	3.5971	32.7	.278	17.7	193.0	210.7		0.049	0.583
− 96	364	20.5	35.2	0.03067	3.4483	32.6	.290	19.0	192.5	211.5		0.052	0.582
− 94	366	22 2	36.9	0.03076	3.3003	32.5	.303	20.2	192.0	212.2		0.055	0 580
− 92	368	24.3	39.	0.03085	3.1348	32.4	.319	21.4	191.6	213.0		0.058	0.579
− 90	370	26.4	41.1	0.03096	2.9851	32.3	.335	22.6	191.0	213.5		0.060	0.577
− 88	372	28.5	43.2	0.03104	2.8571	32.25	.350	23.8	190.5	214.2		0.064	0.576
− 86	374	30.5	45.2	0.03112	2.7322	32.2	.366	25.0	190.1	215.0		0.067	0.575
− 84	376	32.6	47.3	0.03120	2.6178	32.1	.382	26.2	189.5	215.7		0.070	0.573
− 82	378	30.7	49.4	0.03128	2.5126	32.0	.398	27.4	188.9	216.3		0.073	0.572
− 80	380	36.8	51.5	0.03135	2.4155	31.9	.414	28.7	188.4	217.0		0.076	0.571
− 78	382	38.9	53.6	0.03143	2.3310	31.8	.429	29.9	187.8	217.7		0.078	0.569
− 76	384	41.7	56.3	0.03151	2.2173	31.75	.451	31.1	187.2	217.3		0.081	0.568
− 74	386	44.3	59.0	0.03159	2.1186	31.7	.472	32.3	186.6	219.0		0.084	0.567
− 72	388	47.0	61.7	0.03167	2.0284	31.6	.493	33.5	186.0	219.5		0.087	0.565
− 70	390	49.7	64.4	0.03175	1.9455	31.5	.514	34.8	185.4	220.2		0.089	0.564
− 68	392	52.5	67.2	0.03184	1.8692	31.4	.535	36.1	184.8	220.9		0.092	0 563
− 66	394	55.3	70.0	0.03193	1.80118	31.3	.555	37.3	184.2	221.5		0.095	0.562
− 64	396	57.9	72.6	0.03202	1.7361	31.25	.576	38.6	183.6	222.2		0.097	0.561
− 62	398	60.7	75.4	0.03211	1.6807	31.15	.595	39.8	182.9	222.7		0.100	0.560
− 60	400	63.4	78.1	0.03220	1.6234	31.05	.616	41.1	182.2	223.3		0.102	0.558
− 58	400	66.5	81.2	0.03232	1.5625	31.00	.640	42.3	181.5	223.8		0.105	0.557
− 56	402	70.1	84.8	0.03244	1.5129	30.9	.661	43.6	180.8	224.4		0.108	0.556
− 54	406	73.7	88.4	0.03256	1 4599	30.8	.685	44.8	180.1	224.9		0.110	0.554
− 52	408	77.2	91.9	0.03268	1.4225	30.65	.703	46.1	179.3	225.5		0.113	0.553
− 50	410	80.8	95.5	0.03279	1.3812	30.5	.724	47.4	178.6	226.0		0.115	0.552
− 48	412	84.5	99.2	0.03290	1.3423	30.4	.745	48.7	177.9	226.6		0.118	0.550
− 46	414	88.1	102.8	0.03301	1.3072	30.3	.765	50.0	177.2	227.2		0.120	0.549
− 44	416	91.8	106.5	0.03312	1.2739	30.2	.785	51.3	176.4	227.7		0.123	0.548
− 42	418	95.4	110.1	0.03323	1.2407	30.1	.806	52.6	175.6	228.2		0.126	0.546
− 40	420	98.3	113.0	0.03333	1.1962	30.0	.836	53.9	174.8	228.1		0.128	0.545
− 38	422	104.0	118.7	0.03343	1.1508	29.9	.869	55.2	174.0	224.2		0.131	0.544
− 36	424	108.6	123.3	0.03353	1.1087	29.85	.902	56.5	173.2	229.7		0.133	0.542
− 34	426	113.3	128.0	0.03363	1.0695	29.75	.935	57.8	172.3	230.1		0.136	0.541
− 32	428	117.9	132.6	0.03373	1.0331	29.7	.968	59.3	171.5	230 8		0.138	0.539
− 30	430	122.6	137.3	0.03383	1.0010	29.6	1.000	60.6	170.6	231.2		0.141	0.538
− 28	432	127.2	141.9	0.03393	0.9671	29.5	1.034	61.9	169.8	231.7		0.143	0.536
− 26	434	131.8	146.5	0.03403	0.9381	29.4	1.066	63.3	168.9	232.2		0.146	0.535
− 24	436	136.4	151.1	0.03413	0.9107	29.3	1.097	64.6	167.9	232.5		0 148	0.533
− 22	438	141.6	156.3	0.03423	0.8204	29.2	1.210	66.0	167.0	233.0		0.150	0.532
− 20	440	147.2	161.9	0.03436	0.7937	29.1	1.26	67.3	166.1	233.4		0.153	0.530
− 18	442	152.8	167.5	0.03448	0.7692	29.0	1.30	68.7	165.1	233.8		0.155	0.529
− 16	444	158.6	173.3	0.03460	0.7407	28.9	1.35	70.1	164.1	234.2		0.158	0.528
− 14	446	164.3	179.0	0.03472	0.7143	28.8	1.40	71.5	163.0	234.5		0.160	0.526
− 12	448	170.0	184.7	0.03484	0.6944	28.7	1.44	72.9	162.0	235.0		0.163	0.525
− 10	450	175.8	190.5	0.03496	0.6711	28.6	1.49	74.4	161.0	235.4		0.165	0.523
− 8	452	181.6	196.3	0.03511	0.6494	28.5	1.54	75.7	159.9	235.6		0.167	0.522
− 6	454	187.3	202.0	0.03526	0.6289	28.35	1.59	77.1	158.8	236.0		0.170	0.520
− 4	456	193.4	208.1	0.03541	0.6061	28.2	1.65	78.5	157.7	236.2		0.172	0.519
− 2	458	200.5	215.2	0.03556	0.5848	28.1	1.71	79.9	156.6	236.5		0.175	0.517
0	460	207.6	222.3	0.03592	0.5650	28.0	1.77	81.3	155.4	236.7		0.177	0.515
+ 2	462	214.7	229.4	0.03690	0.5464	27.9	1.83	82.8	154.1	237.0		0.178	0.513
+ 4	464	221.8	236.5	0.03608	0.5291	27.75	1.89	84.3	152.9	237.2		0.179	0.512
+ 6	466	228.8	243.5	0.03626	0.5128	27.6	1.95	85.8	151.7	237.5		0.181	0.510
+ 8	468	235.9	250.6	0.03644	0.4975	27.5	2.01	87.3	150.4	237.7		0.182	0.508
+ 10	470	243.1	257.8	0.03663	0.4808	27.3	2.08	88.8	149.0	237.8		0.185	0.506
+ 12	472	250.2	264.9	0.03699	0.4673	27.2	2.14	90.3	147.5	237.8		0.189	0.504
+ 14	474	257.4	272.1	0.03695	0.4505	27.0	2.22	91.8	146.0	237.8		0.192	0.502
+ 16	476	265.5	280.2	0.03711	0.4386	26.9	2.28	93.2	144.6	237.8		0.195	0.500
+ 18	478	273.7	288.4	0.03727	0.4237	26.8	2.36	94.8	143.2	238.0		0.198	0.498
+ 20	480	282.0	296.7	0.03745	0.4098	26.7	2.44	96.4	141.8	238.1		0.201	0.496
+ 22	482	290.3	305.0	0.03762	0.3984	26.6	2.51	97.9	140.3	238.2		0.203	0 495
+ 24	484	298.6	313.3	0.03779	0.3861	26.4	2.59	99.5	138.9	232.4		0.205	0.493
+ 26	486	306.9	321.6	0.03796	0.3745	26.3	2.67	101.1	137.4	238.5		0.208	0.491
+ 28	488	315.3	330.0	0.03813	0.3636	26 2	2.75	102.7	135.6	238.3		0.210	0.489
+ 30	490	323.3	338.0	0.03831	0.3546	26.1	2.82	104.3	133.7	238.0		0.213	0.487
+ 32	492	331.6	346.33	0.03855	0.3460	25.0	2.89	105.9	131.9	237.8		0.215	0.484
+ 34	494	342.5	357.2	0.03899	0.3390	25.8	2.95	107.5	130.0	237.5		0.218	0.481
+ 36	496	353.3	368.0	0.03903	0.3205	25.7	3.12	109.2	128.2	237.4		0.220	0.479
38	498	364.0	378.7	0.03927	0.3096	25.5	3.23	110.9	126.3	237.2		0.223	0.477
40	500	374.7	389.4	0.03953	0.2994	25.3	3.34	112.6	124.5	237.1		0.225	0.475
42	502	385.3	400.0	0.03982	0.2899	25.1	3.45	114.3	122.6	237.0		0.228	0.472
44	504	395.8	410.5	0.04011	0.2809	25.0	3.56	116.0	120.8	236.8		0.230	0.470
46	506	506.0	406.3	0.04040	0.2727	24.8	3.67	117.8	118.5	236.3		0.233	0.467
48	508	416.8	431.5	0.04069	0.2646	24.6	3.78	119.6	116.2	235.8		0.235	0.464
50	510	427.6	442.3	0.04099	0.2571	24.4	3.89	121.3	113.9	235.2		0.238	0.461
52	512	439.6	454.3	0.04134	0.2469	24.2	4.05	123.1	111.6	234.7		0.241	0.459
54	514	451.3	466.0	0.04169	0.2370	24.0	4.22	124.9	109.1	234.0		0.243	0.455
56	516	463.6	478.3	0.04204	0.2283	23.8	4.38	126.9	106.4	233.3		0.246	0.452
58	518	475.8	490.5	0.04239	0.2203	23.6	4.54	128.8	103.7	232.5		0.249	0.449
60	520	488.3	503.0	0.04273	0.2128	23.4	4.70	130.7	101.0	231.7		0.251	0.445
62	522	500.3	515.0	0.04323	0.2070	23.2	4.83	132.6	98.3	230.9		0.254	0.442
64	524	512.3	527.0	0.04373	0.1992	23.0	5.02	134.8	94.9	229.7		0.257	0.438
66	526	524.3	539.0	0.04423	0.1931	22.8	5.18	136.9	91.4	228.3		0.260	0.434
68	528	538.5	553.2	0.04473	0.1852	22.5	5.40	139.0	88.0	227.0		0.263	0.430
70	530	553.6	568.3	0.04525	0.1736	22.1	5.76	141.1	84.6	225.7		0.267	0.426
72	532	568.6	583.3	0.04626	0.1618	21.6	6.18	143.4	80.4	228.8		0.270	0.421
74	534	583.8	598.5	0.04727	0.1538	21.2	6.50	145.6	75.7	221.3		0.273	0.415
76	536	598.5	613.2	0.04828	0.1449	20.7	6.90	147.9	71.0	218.9		0.276	0.409
78	538	612.5	612.5	0.04929	0.1369	20.3	7.30	150.2	66.4	216.6		0.279	0.402
80	540	626.6	641.3	0.05030	0.1299	19.9	7.70	152.4	61.6	214.0		0.282	0.396
82	542	640.5	655.2	0.05481	0.1235	19.5	8.10	158.8	57.8	216.6		0.293	0.399
84	544	654.3	669.0	0.05932	0.1176	19.0	8.50	165.3	45.8	211.0		0.305	0.388
86	546	667.7	682.4	0.06383	0.1053	18.0	9.50	171.8	30.3	202.1		0.316	0.370
88	548	683.0	697.7	0.06834	0.08333	15.4	12.00	178.2	10.4	188.6		0.327	0.344
89.36	549.36	693.84	708.54	0.07283	0.07283	13.728	13.728	183.0	.....	183.0		0.333	0.333

TABLE III
Equivalent Values of Electrical, Mechanical and Heat Units

Unit	Equivalent Value in Other Units
1 K.W. Hour=	1,000 watt hours. 1,341 horsepower hours. 2,655,200 ft. lb. 3,600,000 joules. 3,415 heat units. 367,100 kilogram meters. 0.234 lb. carbon oxidised with perfect efficiency. 3.52 lb. water evaporation from and at 212° F. 22.77 lb. of water raised from 62° F. to 212° F.
1 H.P. Hour=	0.7457 K.W. hour. 1,980,000 ft. lb. 2,546.5 heat units. 273,740 kilogram meters. 0.174 lb. carbon oxidised with perfect efficiency. 2.62 lb. water evaporation from and at 212° F. 17.0 lb. water raised from 62° F. to 212° F.
1 Kilowatt=	1,000 Watts. 1.3410 horsepower 2,355,200 ft. lb. per hour. 44,254 ft. lb. per minute. 737.56 ft. per second. 3,415 heat units per hour. 56.92 heat units per minuts. 0.9486 heat units per second. 0.234 lb. carbon oxidised per hour. 3.52 water evaporation per hour from and at 212° F.
1 H.P.=	745.7 watts. 0.7457 K.W. 33,000 ft. lb. per minute. 550 ft. lb. per second. 2,546.5 heat units per hour. 42.44 heat units per minute. 0.707 heat units per second. 0.174 lb. carbon oxidised per hour. 2.62 lb. water evaporation per hour from and at 212° F.
1 joule=	1 Watt second. 0.000000278 K.W. hour. 0.10197 kilogram meter. 0.0009486 heat units. 0.73756 ft. lb.
1 Ft. Lb.=	1.3558 joules. 0.13826 kilogram meter. 0.0000003766 K.W. hour. 0.0012861 heat unit. 0.0000005 H.P. hour.
1 Watt=	1 joule per second. 0.001341 H.P. 3.415 heat units per second. 0.0035 lb. water evaporation per hour. 44.254 ft. lb. per minute.
1 Watt per Sq. In.=	8.20 heat units per sq. ft. per minute. 6,373 ft. lb. per sq. ft. per minute. 0.1931 H.P. per sq. ft.
1 Heat Unit=	1,054.2 watt seconds. 777.54 ft. lb. 107.5 kilogram meters. 0.0002928 K.W. hour. 0.0003927 H.P. hour. 0.0000685 lb. carbon oxidised. 0.001030 lb. water evaporation from and at 212° F.
1 Heat Unit per sq. ft. per min.=	0.1220 watt per sq. in. 0.01757 K.W. per sq. ft. 0.02356 H.P. per sq. ft.
1 Kilogram Meter=	7.233 ft. lb. 0.000003653 H.P. hour. 0.000002724 K.W. hour. 0.009302 heat unit.
1 lb. Carbon Oxidised Perfect efficiency=	14,600 heat units. 1.11 lb. Anthracite coal oxidised. 2.5 lb. dry wood oxidised. 22 cu. ft. illuminating gas. 4.275 K.W. hour 5.733 H.P. hour. 11,352,000 ft. lb. 15.05 lb. of water evaporation from and at 212° F.
1 lb. Water Evaporation from and at 212° F.=	0.2841 K.W. hour. 0.3811 H.P. hour. 970.4 heat units. 104,320 kilogram meter. 1,023,000 joules. 754,525 ft. lb. 0.066466 lb. carbon oxidised.

example saturated liquid ethane (Table II) at — 10° F. = 31.05 lbs. per cu. ft. = 1/v. Taking water = 62.4 lb. per cu. ft. the specific gravity would be $\frac{31.05}{62.4} = 0.4975$ and water equals 8.33 lb. per gallon.

$8.33 \times 0.4975 = 4.14$ lb. per gal.

VAPOR VOLUME

It has been a more or less general practice to assume that vapor volumes follow the perfect gas laws in calculations involving the design and operation of equipment.

This leads to rather serious errors at higher pressures as may be shown by selecting an actual volume at random from the tables. Thus ethane at 20° F. 1 lb. = 0.4098 cu. ft. vapor. The calculated value (ideal gas law) would be:

359.4 = Molal volume at 32° F. and 1 atmosphere.
Mol. Wt. = 30.05

$$\frac{359.4 \times 480 \times 14.7}{492 \times 30.05 \times 296.7} = 0.5788 \text{ cu. ft.}$$

or 140% of the actual value.

SEPARATION BY FRACTIONATION

Assume a liquid mixture consisting of 80 lb. of methane and 250 lb. of ethane is to be separated by fractional distillation:

$\frac{80}{16.03} = 4.98$ mols. methane.

$\frac{250}{30.05} = 8.32$ mols. ethane.

Total 13.30 mols. mixture.

$\frac{4.98}{13.30} = 0.3745$ mol. fraction of methane.

$\frac{8.32}{13.30} = 0.6255$ mol. fraction of ethane.

Suppose a reflux temperature of — 140° F. may be maintained which would correspond to 397.6 lb. Abs. vapor pressure for methane. If some ethane is in the kettle at the bottom of the column its temperature would have to correspond to a pressure of about 2.5 lbs. higher for differential pressure drop through column. This would be 397.6+2.5=400.1 lb. which corresponds to a temperature of 44° F. for ethane. The approximate condition would then be Kettle Temp. = 44° F., reflux temperature — 140° F., operating pressure=400.1 — 14.7=385.4 lb. ga. A method for calculating the number of plates will be given in a subsequent article. As the temperatures required in the column for the equilibrium on the plates are beyond the range of temperatures on the vapor pressure curve for methane, extrapolated values for its vapor pressure in solution must be used. In other words, methane may remain in liquid solution above its critical point.

Correlating Comparison of Chart Interpretations

F. B. TAYLOR
Panhandle Eastern Pipe Line Company
Stinnett, Texas

THE introduction and use of direct-reading orifice meter charts for natural gas measurement has necessitated accurate atmospheric pressure standards for the particular localities in which they are used. Also, due to the fact that many companies and affiliates employ both the standard and the direct-reading charts on meters of all differential and pressure ranges, it is necessary for the man in the field to have at hand a means of correlating the readings of each.

As a general rule the setting of the static indicator at a positive zero on standard charts is not a necessity, provided that the pressure fluctuation is relatively narrow; correct measurement being obtained if the pressure is correctly interpreted at the working ranges. Conversely, with the direct-reading charts, which indicate the square root of the absolute pressure (or the atmospheric pressure plus gauge pressure), the setting of the lower limit of the static becomes a function of the measurement.

TRANSPOSITION OF DIFFERENTIAL READINGS

Regardless of the range of chart or meter in use, provided that measurement is dependent upon an orifice, the flow will be recorded in actual inches of water displacement, or the square root of this displacement. A differential reading on a standard chart on a 100-inch meter may then be directly transposed to a direct-reading chart merely by extracting the square root of the differential reading. However, if the range of the meter is 50 inches rather than 100; and as the scale of the direct-reading chart is the same for all ranges of meters, the standard differential recording must be multiplied by $\frac{100}{50}$ before the square root is extracted.

By the application of this principle to all standard differential ranges the following formula is derived:

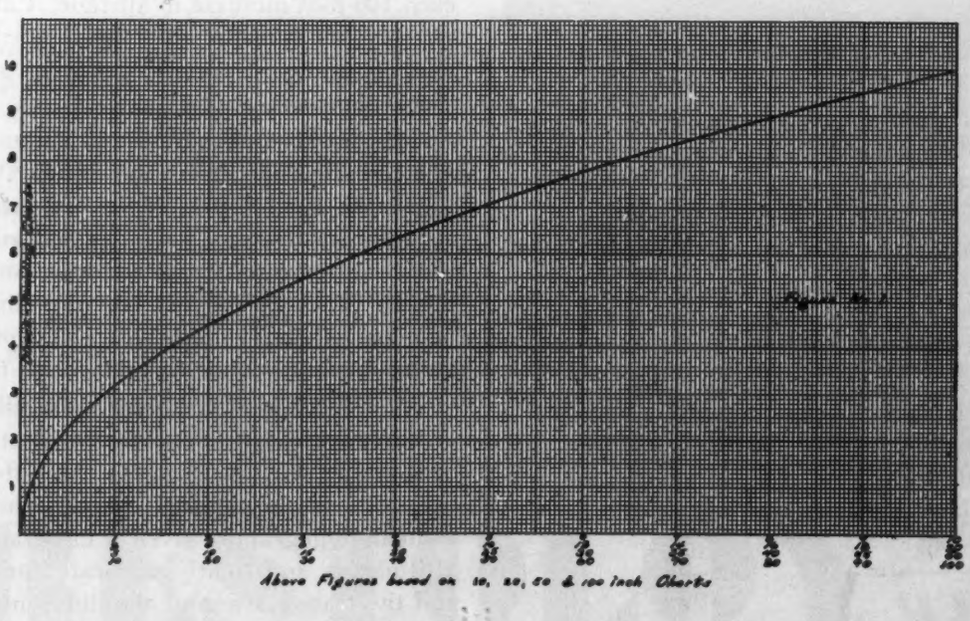
FORMULA A.

$$q = \sqrt{\text{ad.}\frac{100}{\text{mr}}}$$

where,

q = direct-reading chart recording
ad = actual differential in inches of water
mr = Maximum range of meter in inches of water.

Figure 1, computed by George B. Steele of New York Oil Company, Casper, Wyoming, is a graphic



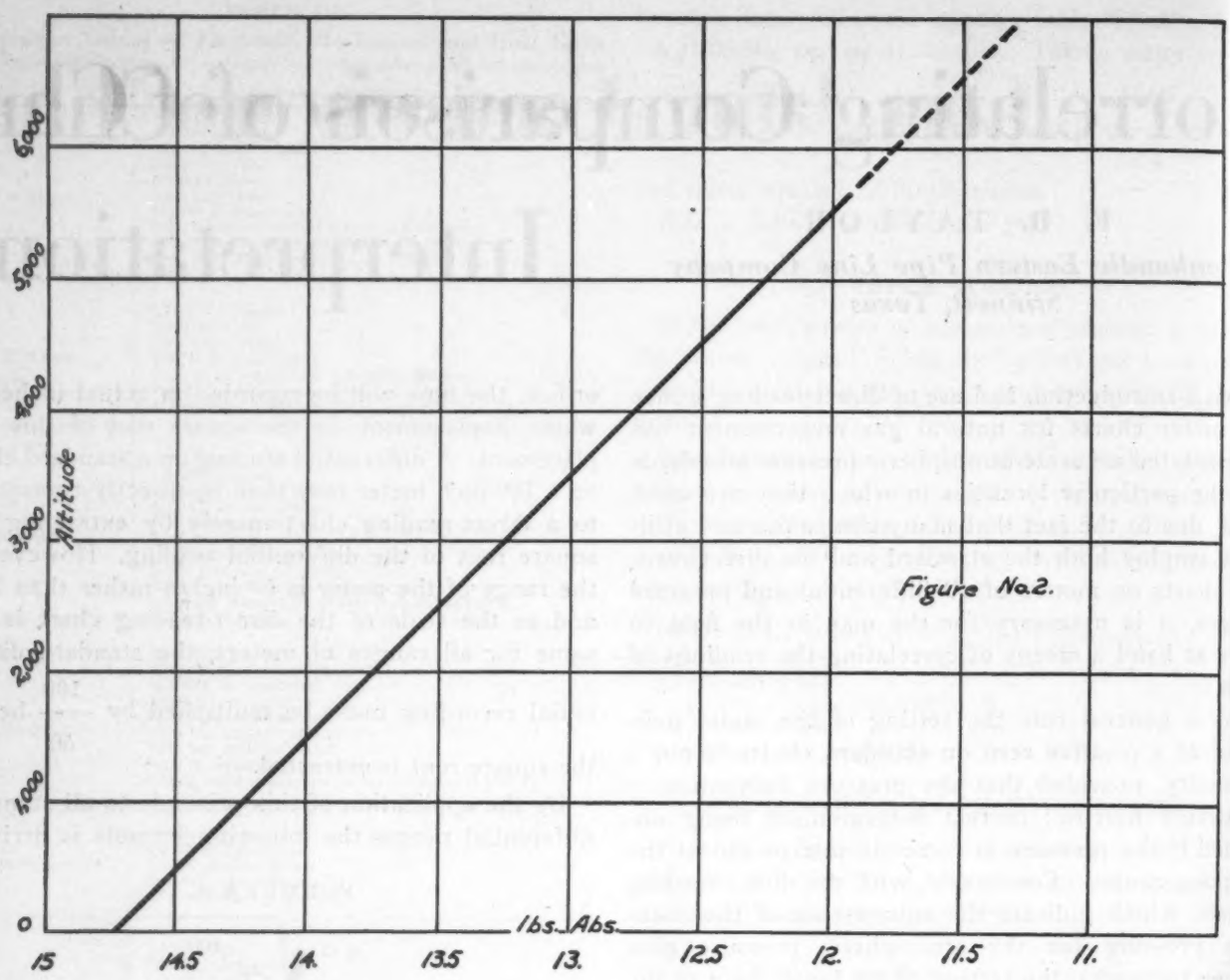


Figure No.2.

expression of this principle and is a ready means of transposing any standard chart recording to a direct recording, or the reverse.

STATIC ZERO ON DIRECT-READING CHARTS

As the pressure is recorded on the direct-reading charts as the square root of absolute pressure, the working zero will be above the actual zero line of the chart in proportion to the square root of the atmospheric pressure. And as pressure gauge springs are of different ranges, the arc through which the indicator arm will travel above absolute zero to the square root of the absolute atmospheric pressure on the direct-reading chart is longer for springs of short range than for the heavier type. As a consequence, the setting of the indicator to correspond with the local atmospheric pressure varies with the spring. This is exactly opposite the manner of setting the static indicator on the standard charts wherein the chart itself is graduated to the particular range of spring in use.

Given that the atmospheric pressure is known. The point at which that static indicator should be set for lower limit on the direct-reading charts again involves Formula A., but substituting, as,

$$q = \sqrt{\text{ad.}\frac{100}{\text{mr}}}$$

where,

q = static position on direct-reading chart at zero gauge pressure
ad = local atmospheric gauge pressure
mr = maximum range of gauge spring

Generally, there is a relationship between the altitude and the atmospheric pressure in the ratio of approximately .05 pounds decrease in pressure to each 100 foot increase in altitude. Calculations based on this relationship must be temperature corrected and subtracted from the accepted standard atmospheric pressure.

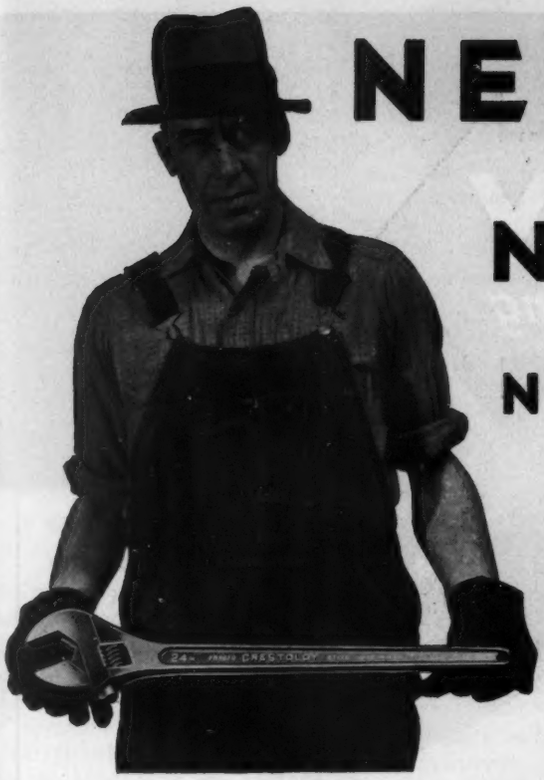
The absolute pressure graph, Figure 2, is an average compiled by the United States Weather Bureau. However, local atmospheric pressure can most accurately be obtained from correlated data from repeated observations with accurate and tested instruments. These pressures are not uniform, as might be expected, and change with the depth of the earth's atmospheric envelope in relation to the latitude.

The precision of recording the absolute pressure on direct-reading charts is dependent upon a correct zero-gauge setting. Zero on the differential scale is the same as on standard charts. The use of the accompanying graphs, given a close approximation of altitude, is sufficiently accurate for all field work, and the transposition of the differentials is exact.

NEW IN SIZE

NEW IN DESIGN

NEW IN PERFORMANCE



The 24 inch CRESTOLOY WRENCH

What a Wrench! **Twenty-four inches long: weighs nine pounds: opens to 2 7/16 inches. Built for tough jobs . . . made to start in where the little fellows leave off.**

And this wrench is as trim as it is husky. Well-balanced, easy to use. Quick-adjusting, precision-fitting jaws provide that famous Crescent *safety-fit* on any nut up to 1 1/2″ U S Std. The handle design is new . . . tapering slightly from the head to permit the use of pipe handle extensions. Yes sir, this tool is built for *work* . . . and lots of it.

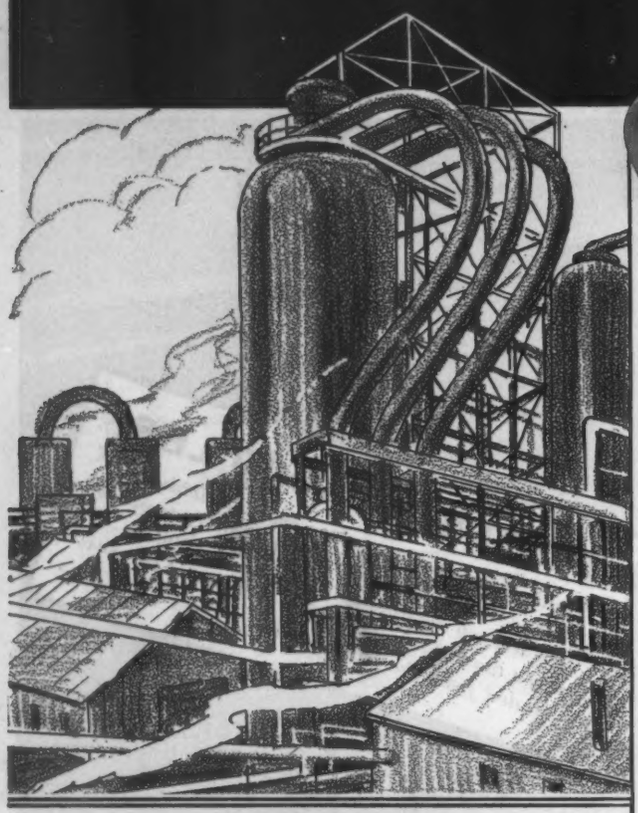
The steel, of course, is CRESTOLOY. That accounts for the unusual strength and clean-limbed design. Finish is chrome-plate, with heads polished bright . . . smooth, durable, easy on hand and eye alike. Price . . $7.50. Ask your supplier or write today for literature and test data.

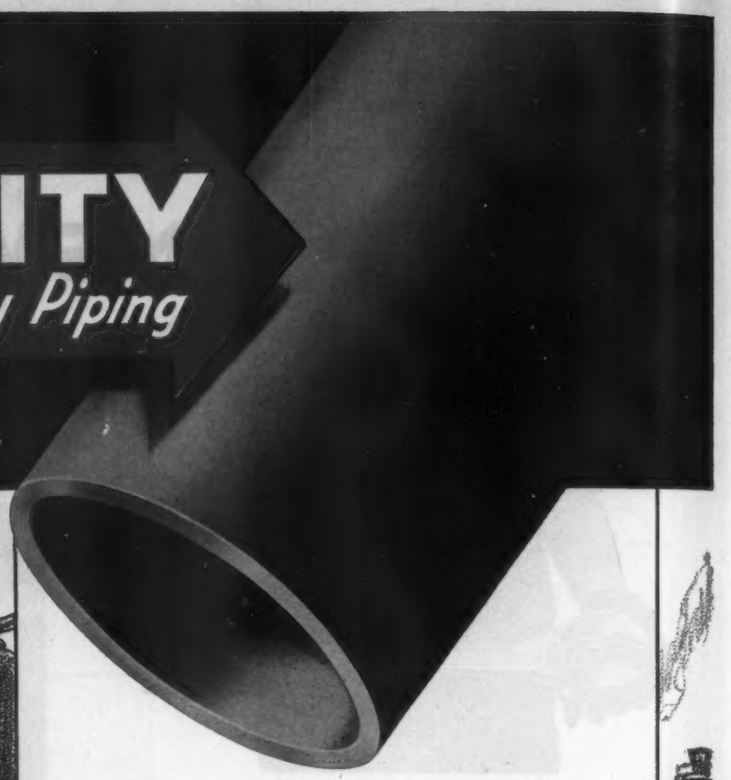
CRESCENT TOOL COMPANY
Jamestown, N. Y.

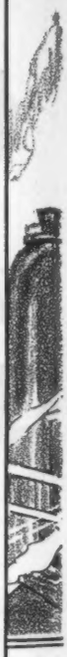
TESTED TO 1900 LBS.
That's the routine test given every individual 24 inch Crestoloy Wrench. Destruction Tests prove this wrench capable of loads up to 2900 lbs . . . more than the weight of a 1935 Ford car suspended from the handle hole.

CRESTOLOY STEEL WRENCH

RELIABILITY
counts most in Refinery Piping







In modern refineries, where high pressures, high temperatures, and severe corrosive conditions are involved, reliability of equipment would seem to be the paramount consideration. Here the elements of direct cost, of safety, and of continuous operation can be turned toward either success or failure. This is why leading refiners, continually on the search for new and better tubular material, are turning more and more to National Tube Company 4%—6% Chromium Pipe and Tubes for still tubes and also for furnace tubing, hot oil lines, tubular parts of heat exchangers, condenser tubing, return bends, etc.

Some of the main advantages of NATIONAL 4%—6% Chromium Pipe and Tubes are high resistance to corrosion; unusual resistance to oxidation or scaling; exceptional ductility for bending and forming; improved strength at high temperatures. They are made from electric-furnace steel of the highest quality and, being seamless—no welds—have uniform wall-strength throughout. This material can be sentry drilled (an exclusive feature) when so ordered.

Write NATIONAL engineers and metallurgists on your problems. Information and literature will be sent on request.

NATIONAL TUBE COMPANY
PITTSBURGH, PA.
Export Distributors—UNITED STATES STEEL PRODUCTS CO., New York

United States Steel Corporation Subsidiary

NATIONAL TUBE COMPANY
4%-6% CHROMIUM
SEAMLESS PIPE AND TUBES WITH ½% MOLYBDENUM

The Look Box

(*Continued from page* 198)

A.P.I. Mid-Year Meeting Program

TWENTY-FIVE papers, chiefly technical in scope, are scheduled for presentation on the preliminary program of the American Petroleum Institute's fifth mid-year meeting to be held May 14, 15, and 16 in the Mayo Hotel at Tulsa, Oklahoma. Some 40 committee meetings, and regular sessions of the Board of Directors, also are listed on the preliminary program, which is subject to revision.

The program calls chiefly for divisional sessions, with no general session scheduled. The Division of Marketing will hold no meetings, but several marketing committees will meet.

The program follows:

Wednesday, May 15

9:30 a.m., Division of Production, Crystal Ball Room, Drilling and Production Practice program sponsored by Central Committee on Drilling and Production Practice. Papers on following subjects under consideration: Blowout Prevention; Direct-Drive Diesel Engines; Resistance to Mud Flow in Tool Joints; Disposal of Salt Water.

10:00 a.m., Division of Refining, Junior Ball Room, Refinery session.

The Chemical Constitution of the Gasoline Fraction of Petroleum, Frederick D. Rossini, National Bureau of Standards.

Fundamental Research on the Chemical Constitution of Lubricating Oil, Frederick D. Rossini, National Bureau of Standards.

Determination of Monthly Gasoline-production Allowables, Fred Van Covern, Planning and Coordination Committee.

Laboratory Distilling Apparatus, W. W. Scheumann and J. F. Stewart, Empire Oil & Refining Company.

2:00 p.m., Division of Refining, Junior Ball Room, Refinery session.

Diesel-Fuel Specifications— Round Table discussion.

Oiliness in Motor Oil Practice, E. R. Barnard and D. P. Barnard, IV, Standard Oil Company (Indiana.)

Polymer Gasoline from Cracked Gases, Gustav Egloff and V. N. Ipatieff, Universal Oil Products Company.

Thursday, May 16

9:30 a.m., Division of Production, Crystal Ball Room, Drilling and Production Practice program sponsored by Central Committee.

Electrical Logging.

Selective Wetting of Reservoir Rock and Its Relation to Oil Production.

Equipment Used iu Securing and Examining Sub-Surface Samples.

Sub-Surface Pressure Instruments.

10:00 a.m., Division of Refining, Junior Ball Room, Progress in Solvent Refining.

Recent Developments in Solvent Extraction with Chlorex, D. B. Williams, Carbon and Carbide Chemical Corporation.

Performance and Flexibility of Duo-Sol Process Malcolm Tuttle, Max B. Miller Company.

The Refining of Lubricating Oils with Furfural, G. R. Bryant, R. E. Manley, and B. Y. McCarty, The Texas Company.

Analytical Solvent Fractionation, U. B. Bray, D. R. Merrill, and R. C. Pollock, Union Oil Company of California.

Some Effects of Solvent Fractionation on Service Characteristics of Motor Oils, D. R. Merrill, C. C .Moore, Jr., and U. B. Bray, Union Oil Company of California.

2:00 p.m., Division of Production, Crystal Ball Room, Drilling and Production Practice program sponsored by Central Committee.

Papers on following subjects now being considered: Mid-Continent Production Methods; Frozen Drill Pipe and Cement-Casing Bonds; Directional Drilling; Oil-Well Casing; and Integral-Joint Drill Pipe.

The entire day Tuesday, May 14, is to be given over to committee meetings. Definite dates and hours for the meetings have not been selected.

Conventions

A. I. C. E. May 14-16, American Institute of Chemical Engineers will meet for its semi-annual convention in Wilmington, Delaware.

A. P. I. American Petroleum Institute will hold its fifth mid-year meeting in Tulsa, May 14, 15, 16.

A. S. C. E. The American Society of Chemical Engineers, holds its meeting in Cincinnati, Ohio, June 19-21.

P. G. C. O. A. Pennsylvania Grade Crude Oil Association plans to hold its annual convention at State College, Pennsylvania, June 20 and 21.

A. S. T. M. American Society for Testing Materials annual meeting is scheduled for June 24 to 28 at Detroit, Michigan.

N. P. A. The National Petroleum Association, September 25-27, will hold its annual meeting at Atlantic City.

N. S. C. National Safety Council holds the twenty-fourth annual Safety Congress, in Louisville, Kentucky, October 14-18.

A. P. I. The American Petroleum Institute will hold its 16th annual meeting at the Biltmore Hotel, Los Angeles, November 11-14.

C. N. G. A. The California Natural Gasoline Association holds its meeting the first Thursday of every month in the Richfield Building, Los Angeles. California.

Organize ASA Committee On Petroleum Products

THE American Standards Association is organizing under the sponsorship of the American Society for Testing Materials a new sectional committee on petroleum products and lubricants, the scope of which will include nomenclature, methods of test, and specifications. When the organization has been completed, the new sectional committee will replace Committee Z-11 on Nomenclature and Methods of Test for Petroleum Products and Lubricants which is identical in personnel with ASTM Committee D-2 on Petroleum Products and Lubricants, and which includes in its scope only nomenclature and methods of test, and Committee K-19 on Specifications for Fuel Oils which is identical in personnel with Technical Committee C on Fuel Oils (including Diesel Fuel) of ASTM Committee D-2.

The Institute and other trade associations of the petroleum industry have been invited to designate representatives on the new sectional committee.

C.N.G.A. May Meeting

DESCRIBING an apparatus that is finding application not only in the natural gasoline plant but in vapor recovery and general refining operations as well, F. L. Kallam of Industrial Engineers, Inc., will describe his continuous vapor pressure recorder at the May meeting of the California Natural Gasoline Association. Utilizing a split-stream sample of gasoline heated to 100°F. the apparatus injects the sample into a float-controlled vapor pressure chamber where the vapor pressure is taken and the result recorded on a continuous vapor pressure and temperature recorder. There will be plenty of lantern slides and interesting descriptions of practical applications.

The other and equally important half of the program will consist of the presentation by E. G. Ragatz and E. R. McCartney, Union Oil Company, of "Some Total Heat Charts for the Components of Natural Gasoline." These men have had wide experience in the application of physical and mathematical data to natural gasoline rectification and the charts which they are to describe will be widely anticipated by every engineer and chemist in California's natural gasoline and refining industries.

Natural Gasoline Association Elects Goebel President

THE fourteenth annual convention of the Natural Gasoline Association of America, held at Tulsa, was welcomed by W. G. Skelly, president of Skelly Oil Company at its opening session Wednesday afternoon, May 1. He commended the association for its technical and practical activities in the furthering of more widespread and appreciative utilization of natural gasoline by the refining branch of the industry and by the motoring public. He complimented the association upon its foresight in the matter of its present technical program wherein several leading technologists and engineers within and from outside the industry are presented in conjunction with scientists and engineers from the automotive and petroleum refining industry. This gathering together of men representing various phases of the manufacturing, marketing and utilization problems affecting natural gasoline, at a place where their mutual and individual technical and practical problems can be brought out into open discussion and interchange of ideas can not help but prove of real and lasting help to all concerned, he stated.

T. R. Goebel, executive assistant, Skelly Oil Company, Tulsa, was elected president of the Natural Gasoline Association of America, succeeding Chris Williams, Continental Oil Company, Ponca City, who has served as president during the past two years. R. E. Haylett, Union Oil Company of California, was elected first vice president; Fred F. Ketchum of the gas department, Owens-Libby-Owens, second vice president, and W. E. Rearden, Columbian Gasoline Corporation, Monroe, third vice president. W. F. Lowe continues as secretary.

D. C. Williams, Continental Oil Company, retiring president of the association, reviewed progress made by the association, and its various committees during the past year and pointed to the important relationship between the work of such committees as the technical committee, gas contract and gas testing committees and the problems of gasoline plant and gasoline company operation. He reported on the progress in cooperative work between the association and other associations studying similar problems. Following the president's address chairmen of various committees made their annual reports to the association and William F. Lowe, secretary, discussed the relationships and progress made with respect to the Petroleum Code and the natural gasoline industry.

Entertainment at the convention meeting, this year as in the past, was furnished by the Natural Gasoline Supply Men's Association and consisted of luncheons Wednesday and Thursday, the annual dance Wednesday night and the annual smoker Thursday night.

At the meeting of the Natural Gasoline Supply Men's Association Wednesday

T. R. GOEBEL

morning the association approved the plan inaugurated this year, of publishing annually a handbook type of bulletin in which important and valuable technical and engineering information is correlated and placed under one cover for use as a handy reference by those engaged in natural gasoline manufacture. Two thousand copies of the first edition of this bulletin were distributed this year and the response accorded the publication apparently warrant its continued compilation and publication.

The supply men's association elected five new directors at the Wednesday meeting to succeed five directors whose terms expired. The following are the newly elected directors: W. D. Moorer, Moorlane Company; D. W. McKay, Cooper-Bessemer Corporation; W. W. Woobank, Woobank Pump & Machinery Company; C. B. Lane, Foxboro Company, and W. A. Schleuter, Refinery Supply Company.

The retiring directors are H. H. Thiphaus, Taylor Instrument Company; M. F. Waters, Hanlon-Waters, Inc.; J. A. Lupfer, Worthington Pump and Machinery Corporation of Oklahoma; M. H. Kotzebue, Tulsa Boiler & Machine Company, and J. H. Satterwhite, Westcoss & Greis.

Thursday's sessions were given over to a symposium on motor fuel volatility trends and the possible effects on automotive engine design and performance. Papers and discussions were presented by A. D. Bauer and A. E. Becker, Standard Oil Development Company; T. B. Rendell, Shell Petroleum Corporation, who presented the refining industry's viewpoint. The automotive industry viewpoint was presented by T. A. Boyd, General Motors Corporation, and J. B. Macauley and Gilbert Way, Chrysler Corporation. The symposium was closed by Dr. G. G. Brown, University of Michigan, giving the natural gasoline industry's viewpoint in his progress report on road tests to determine the advantages of the use of fuels of high volatility in motors designed for their efficient use.

At the final session Firday morning Professor R. L. Huntington, University of Oklahoma, discussed "Stage Separation of Crude Oil-Gas Mixtures," and J. Don Nevius, United States Bureau of Mines, discussed "Bureau of Mines Statistics on Natural Gasoline Production and Distribution.

Division of Petroleum American Chemical Society

THE Division of Petroleum of the American Chemical Society, meeting at New York, April 22 and 23, in conjunction with the American Chemical Industries Tercentenary group, the eighty-ninth meeting of the society experienced perhaps the most important technical convention held in recent years. A total of 29 valuable papers were presented and discussed at this time. The group emphasized several phases of technical development of lasting importance to the petroleum industry. In addition to its program of 13 papers on varied subjects of timely import, a special symposium of 13 papers was presented dealing with the chemistry of gaseous hydrocarbons. The symposium on asphalt included three discussions. The program of papers was as follows:

Division of Petroleum Chemistry

Frank W. Hall, Chairman

C. R. Wagner, Secretary; John Jay Hull, Local Assistant

Gustav Egloff. Three Hundred Years of Oil. A Story of Conservation.

R. T. Leslie. Separation of a Dimeth-

ylcyclohexane Fraction from an Oklahoma Petroleum.

F. W. Rose, Jr., and Joseph D. White. The Isolation of Ethylcyclohexane from an Oklahoma Petroleum.

Beveridge J. Mair and Joseph D. White. The Separation of Petroleum Hydrocarbons with Silica Gel.

S. T. Schicktanz. An Apparatus for Measuring the Boiling Points of Lubricating Oils and Other Compounds of High Molecular Weight at Reduced Pressures.

C. O. Tongberg, D. Quiggle, and M. R. Fenske IV. Composition of Straight-Run Pennsylvania Gasoline, Fractionation of Straight-Run Gasoline.

Walter J. Podbielniak. A New Basic Principle in the Design of Fractionating, Absorbing, and Other Countercurrent Fluid Reacting Equipment.

John M. Campbell, Frank K. Signaigo, Wheeler G. Lovell, and T. A. Boyd. The Effectiveness of Tetraethyllead in Increasing the Critical Compression Ratio of Some Individual Hydrocarbons.

S. D. Turner and E. J. LeRoi. Octane Number Improvement in Naphtha Reforming as a Function of the Time-Temperature Integral.

K. M. Watson, E. F. Nelson, and George B. Murphy. Characterization of Petroleum Fractions.

J. C. Morrell, Wayne Benedict, and Gustav Egloff. Light Effect on Color Stability of Gasoline.

Ralph W. Dornte. The Oxidation of White Oils.

Ogden FitzSimons. A Rapid Precision Viscometer.

Symposium on Asphalt

T. H. Rogers, Chairman

A. Holmes, J. O. Collins, and W. C. Childs. Measuring the Susceptibility of Asphalt to Temperature Changes.

Robert R. Thurston and Edwin C. Knowles. Oxygen Absorption Tests on the Constituents of Asphalt.

Charles Mack and R. K. Stratford. Energy Relations at the Interface between Asphalt and Mineral Aggregate and Their Measurements.

Symposium on the Chemistry of Gaseous Hydrocarbons

C. A. Lunn, Chairman

Joint Symposium with Division of gas and Fuel Chemistry. W. E. Kuhn, L. C. Kemp, Jr., and J. F. Collins, Jr. Improvements in Effusion Method for Determining the Specific Gravity of Gases.

Wallace A. McMillan, Howard A. Cole, and A. V. Ritchie. Determination of Gaseous Olefins or Hydrogen by Catalytic Hydrogenation.

Louis S. Kassel. The Mechanism of

ENGINEERING KNOWLEDGE

FISHER AUTOMATIC CONTROL

Proper selection and application of pressure regulators, liquid level controllers, and similar automatic controls has fast developed into a specialized branch of engineering—control engineering. Fisher Governor Company maintains a staff of engineers highly trained in this work who will gladly help you on the selection of the correct type or size of regulator to best meet the requirements of your installation. There is no obligation for this service.

Complete "Valve Sizing" charts, such as the engineers, above, are using, enables you to easily size FISHER Regulators for all fluid or pressure conditions. These charts are printed in handy bulletin form. Your copy will be mailed upon request.

FISHER CAN TELL US JUST WHERE WE ARE WRONG

FISHER CAN GIVE US THE CAPACITY OF THAT VALVE

FISHER GOVERNOR COMPANY

2334 E. EIGHTH STREET, LOS ANGELES, CALIF. — 50 CHURCH STREET, NEW YORK, N. Y.

201 SOUTH FIRST AVENUE, MARSHALLTOWN, IOWA

Pioneers lead the way to prosperity

Cracking Units produce high-quality distillates most economically, efficiently and safely when lime, of the proper quality, is added to the charging stock entering the still. Our 24-page booklet "Pioneer Lime—A Contribution to Oil Refining Efficiency" explains how lime functions to prevent corrosion; facilitate coke removal, and promote "B. S." separation, and why **Pioneer Oyster-Shell Lime** is especially adapted to these operations. A copy is yours on request.

THE HADEN LIME COMPANY

MFRS. OF PIONEER OYSTER SHELL LIME

1720 SHEPHERD STREET

HOUSTON-TEXAS

Thermal Decomposition of the Paraffins.

F. O. Rice and O. L. Polly. The Formation of Alicyclic Hydrocarbons from Free Radicals.

H. H. Storch. Kinetics of Ethylene Polymerization. II.

Gustav Egloff and Edith Wilson. Relations of Thermal Reactions of Gaseous Paraffins, Olefins, Acetylenes, and Cycloparaffins.

Frank C. Whitmore and Robert F. Marschner. The Polymerization of Propylene.

Per K. Frolich and Peter J. Wiezevich. Cracking and Polymerization of Low Molecular Weight Hydrocarbons.

Hans Tropsch and Gustav Egloff. Pyrolysis of Gaseous Paraffin Hydrocarbons.

V. N. Ipatieff. Catalytic Polymerization of Gaseous Olefins by Liquid Phosphoric Acid.

F. W. Sullivan, Jr., R. F. Ruthruff, and W. E. Kuentzel. Pyrolysis and Polymerization of Gaseous Paraffins and Olefins.

C. R. Wagner. The Production of Gasoline by Polymerization of Olefins.

V. N. Ipatieff, B. B. Corson, and Gustav Egloff. Gasoline from Cracking Still Gases.

New P.A.B. Field Office

The Petroleum Administrative Board has established a new field office in the United States National Bank Building, 817 17th Street, Denver, Colorado, to deal with Petroleum Code problems in the Rocky Mountain area. Charles A. Graham, a native of Denver, and a member of the legal staff of the board for the past year, will be in charge of the office. He is a graduate of Yale University and of Yale Law School.

D. J. Moran Elected Treasurer of A. P. I.

AMERICAN Petroleum Institute directors at Chicago, May 3, elected D. J. Moran, Continental Oil Company, New York, treasurer of the institute to succeed Frank Phillips, Phillips Petroleum Company, New York, who has resigned. C. M. Boggs, Kanotex Refining Company, Arkansas City, Kansas, was elected a director to succeed Howard Bennette, deceased. Harry A. Logan, Unitel Refining Company, Warren, Pennsylvania, was elected a director to succeed Frank Fretter, deceased. Both directory terms expire in 1936.

Institute Directors Oppose Federal Control of Business

DIRECTORS of the American Petroleum Institute, meeting in an eight-hour session at Chicago May 3, unanimously adopted a petition to Congress opposing the Harrison Bill and similar "economic straight jackets" providing for enlargement of the NIRA, urging that government of oil producing states be encouraged to exert their power to regulate production of crude oil and natural gas, and suggesting a course of action for the federal government in enacting legislation directly affecting the petroleum industry.

The six-page petition, which is to be filed with congress next week, established five principles which, the board of directors said, materially would assist in stabilizing conditions under which the petroleum industry can operate to direct advantage of both makers and users of petroleum products.

Minimum of Regulation

The first principle called for a minimum of regulation so that private industry may be free to serve the public most efficiently and economically.

The second principle urged encouragement of state governments in regulating production of crude oil and natural gas to prevent waste.

The third principle suggested that the federal government, having power to deal with interstate and foreign commerce and to authorize interstate compacts, supplement production control of the states by making permanent and enforcing the Connally law prohibiting the shipment of "hot oil," by approving interstate compacts already ratified by five states, by directing the U. S. Bureau of Mines to ascertain crude oil production necessary to meet demand, and by exercising control of imports to a proper ratio to domestic production.

D. J. MORAN

The fourth principle held that in the case of marketing operations there is no reason to select the petroleum industry for special federal intervention, and urged that industrial pacts and agreements voluntarily made by any industry to eliminate unfair methods of competition be permitted.

NIRA Extension

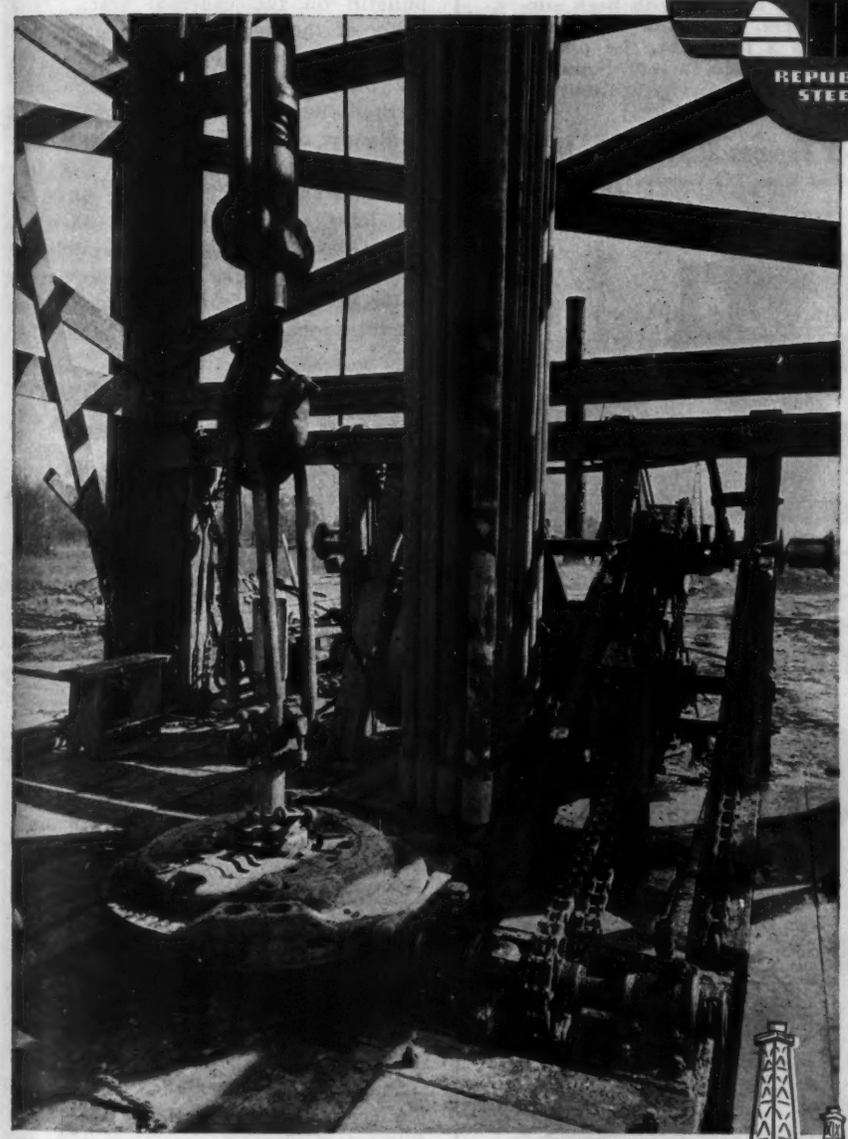
The fifth principle declared that "any such economic straight jacket" as is contained in Senate Bill 2445 or similar proposals for enlargement of the NIRA, would "serve to increase the price of gasoline and demoralize the industry."

The petition struck at the suggestion that the petroleum industry be made a public utility by declaring that while it is the duty and obligation of government to prevent the waste of crude oil and thereby conserve the national supply "there is nothing in the inherent nature of petroleum or in the conduct of the business which requires or justifies the oil industry being declared a public utility any more than in the case of any other producer or manufacturer of a commodity of general use."

Declaring that sufficient progress has been made toward recovery to necessitate the consideration of methods of orderly development of business as a substitute for devices created in emergency and desperation, the petition stated that the time has come to take a long-range view of American economic progress.

"The oil industry is prepared to do its part," the petition stated in conclusion, "and to demonstrate confidence in itself and in the future of the country, if it can but know clearly that its efforts are not to be checkmated by constant change, bureaucratic dictation or usurpation of power. Congress has an unparalleled opportunity to aid recovery by a frank recognition of separate fields of federal and state responsibility under the constitution."

Republic alloy steels are found in the *better* equipment



Steel has made possible many of the mighty strides that have marked the progress of the petroleum industry. And Republic alloy steels can take credit for doing their part in much of the better equipment that has helped operators set new standards of economy and performance.

Republic alloy steels are custom made for each particular class of service—for drilling bits, for strainers, for engine and pump parts, for drive chains, for shafting, for gears, for valves, for still tubes—in fact wherever excessive stresses, vibration, abrasion, corrosion or high temperatures demand the utmost from steel.

Manufacturers and users of every type of equipment used in the producing, refining and distributing of petroleum products will find it profitable to take advantage of the experience gained by Republic's metallurgical staff during many years of contact with the oil industry.

Republic Steel CORPORATION

GENERAL OFFICES · · · YOUNGSTOWN, OHIO
CENTRAL ALLOY DIVISION · · MASSILLON, OHIO

QUIMBY PUMPS

ROTEX SCREW

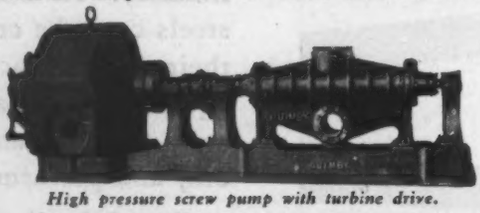
These two Quimby Pumps are suitable for many applications in refineries, handling as they will products ranging from the thin, fluid distillates to the heavy, viscous oils or greases.

Simplicity is an outstanding feature of these two pumps. In each, there are only two moving parts. In the ROTEX Pump, two cams rotate in sealed chambers in fixed relation to each other; the SCREW Pump has two parallel shafts with inter-locking screws which provide the pumping action.

Both the ROTEX and the SCREW Pump can operate with high suction lifts and against high discharge pressures. The flow is smooth and steady. Where the material handled is a lubricant, the pumps are self-lubricating. Maintenance? It's a negligible factor. Some of our SCREW Pumps are rounding out 25 years of service without requiring spare parts.

Quimby Pump Company, 342 Thomas St., Newark, N. J.

Offices in Principal Cities in the United States and Canada

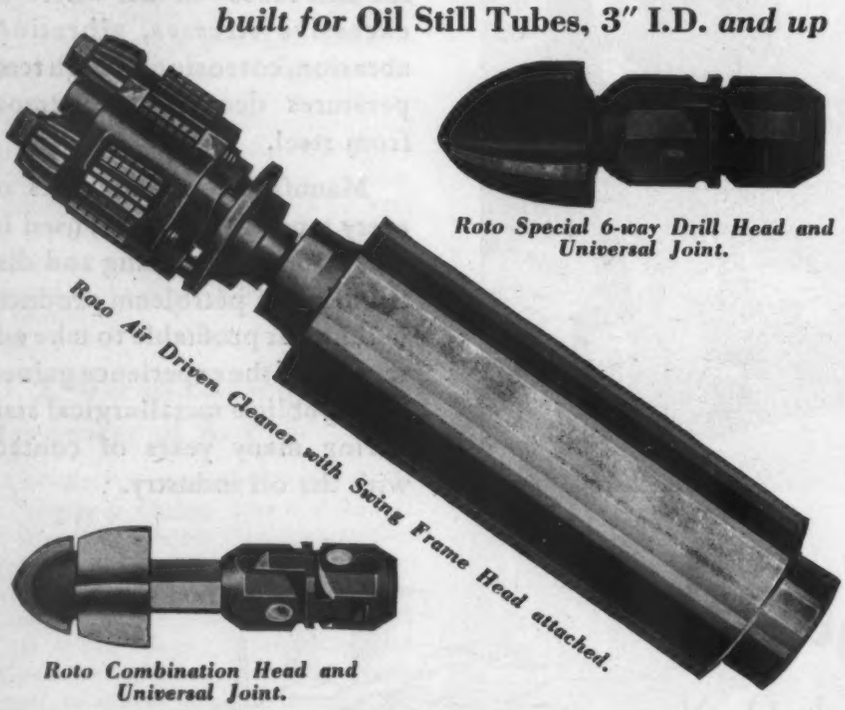


High pressure screw pump with turbine drive.

FOR LOW-COST PUMPING OF WAXES OILS, DISTILLATES AND GREASES

ROTO TUBE CLEANERS

built for* Oil Still Tubes, 3" I.D. *and up



Roto Special 6-way Drill Head and Universal Joint.

Roto Air Driven Cleaner with Swing Frame Head attached.

Roto Combination Head and Universal Joint.

THE ROTO COMPANY

Sussex Avenue and Newark St., Newark, N. J.

C.N.G.A. Technical Investigations

THE 1935 program of cooperative laboratory and engineering investigations being conducted by the California Natural Gasoline Association holds promise of yielding data of great importance to the natural gas and natural gasoline industry, according to P. S. Magruder, chairman of the technical committee. Five committees are actively working on problems dealing with (1) the deviation of natural gas from Boyle's Law; (2) the preparation of a new bulletin on the charcoal test; (3) a study of the new Reid test procedure recently proposed by A. S. T. M.; (4) the preliminary evaluation of a new method developed by Standard Oil Company of California for the controlled weathering of charcoal test condensates under pressure; and (5) the joint participation with the Pacific Coast Gas Association and the Southern California Meter Association in the development of a revised code of gas measurement practice.

Byles and Boyd on Bureau of Mines Board

PRESIDENT Axtell J. Byles and Executive Vice President W. R. Boyd, Jr. of the American Petroleum Institute, with Amos L. Beaty of New York, past president and present member of the Institute's board of directors, have been appointed representatives of the petroleum industry on the newly-created Advisory Board of the United States Bureau of Mines.

Twenty-nine leaders of mining and allied industries compose the board, which, it is believed, will aid the bureau by guiding activities toward more effective service to mineral industries.

B. R. CARNEY, Shell Union Oil Corporation, New York, has been appointed a member of the American Petroleum Institute Committee on Testing Methods and Specifications.

A. R. LANGE, Swann-Finch Corporation, has resigned from membership on the American Petroleum Institute Committee on Testing Methods and Specifications.

HENRY W. JONES, The Atlantic Refining Company, Philadelphia, has been appointed to take the place of S. H. McKenty on the American Petroleum Institute Committee on Accident Prevention in Refineries.

O. D. GURLEY has been appointed superintendent of Omar Refining Company's Garber, Oklahoma, refin-

ery, according to announcement by F. S. and J. H. Whittaker, owners of the company. Mr. Gurley, for the past several years has been with Globe Oil & Refining Company, in charge of operations at its refineries and prior to that was with The Pure Oil Company at its old Cushing refinery.

BYRON B. MORTON, formerly plant metallurgist, Standard Oil Company of Louisiana, Baton Rouge refinery, has joined the staff of the development and research department of International Nickel Company, Inc.

Petroleum Bibliography Published

A GENERAL bibliography of articles on the petroleum industry and related subjects published during July, August, and September, 1934, has been prepared for the use of writers and librarians by the American Petroleum Institute's Department of Public Relations. It supplements the bibliography recently issued to cover the first six months of 1934.

Gasoline Production Allocation for May

THE allowed production of gasoline by refinery districts (including the production of straight run and cracked gasoline and the natural gasoline blended therewith, either at refineries or terminals) has been determined, in accordance with Section 3, Article IV of the Code to be, for the month of May, 1935, as follows:

District	Allowed Gasoline Production Barrels	Required Seasonal Inventory Changes Barrels
1. East Coast	5,810,000	—548,000
2. Appalachian	1,636,000	— 18,000
3. Indiana-Illinois-Kentucky	6,386,000	—352,000
4. Oklahoma-Kansas-Missouri	4,593,000	—671,000
5. Texas:		
(a) Inland Texas	2,092,000	— 48,000
(b) Texas Gulf Coast	6,781,000	—166,000
(c) East Texas	446,000	— 3,000
6. Louisiana-Arkansas:		
(a) Louisiana G. Coast including Alabama	1,251,000	— 17,000
(b) North Louisiana-Arkansas including Mississippi	657,000	— 3,000
7. Rocky Mountain	893,000	— 18,000
8. California	5,313,000	—336,000
	35,858,000	—2,180,000
One percent reserve withheld for appeals	364,000	
Reserve withheld from District 5-C for non-reporting companies	198,000	
Total Allowable Production	36,420,000	

PLANT ACTIVITIES

Gasoline Plant: Phillips Petroleum Company is reported planning erection of a well-pressure natural gasoline plant in the Cooper field, Lea County, New Mexico.

Purchase: Panhandle Refining Company, Wichita Falls, has purchased the refinery and gathering system of Paragon Refining Company, Lueders, Jones County, Texas, and will improve and enlarge capacity. J. C. Hester, formerly with the Paragon concern, will remain as superintendent, under W. F. Simms, refinery manager, Wichita Falls.

Sale: Archer Refining Company, Megargel, has sold its 1500-barrel skimming plant to White and Duncan, and the new operators have changed its name to Plains Gas & Fuel Company, Inc.

Refineries: Ralph Fair, Houston, and associates are reported planning two refining installations in the lower Rio Grande Valley area. A $250,000 cracking installation is reported for Harlingen, Texas. Valley Refining Company has a skimming plant at this point. A $100,000 skimming plant is said to be planned for Sullivan City, Hidalgo County, Texas.

Repairs: Carter Oil Company, Tulsa, will repair damage at its Seminole, Oklahoma, field Stuart gasoline plant caused by tornado which destroyed cooling towers and other equipment. Estimated cost $25,000.

Cracking: Home Oil Refining Company, Great Falls, Montana, is remodeling the refinery, including installation of latest type Dubbs cracking unit of two coil selective cracking design equipped with stabilizer, absorber and special treating system. Additions include boiler and vacuum distillation for asphalt production. Contract to Ralph M. Parsons Company.

Refinery: Hightower Oil & Refining Corporation, operating under a Delaware charter, was recently formed by J. A. Watts and brothers to take over their 1000-barrel capacity crude skimming plant at Brownwood, Texas, formerly identified as the Petroleum Oil Interests, Inc.

Refinery: Panhandle Refining Company, Wichita Falls, Texas, one of the largest independent refiners in North Texas, has purchased Paragon Refining Company's 500-barrel capacity crude skimming plant near Lueders, Texas. The new owner has started work on enlarging the plant capacity, and is also expanding the pipe line system serving shallow oil areas in western Shackelford County.

Refinery: Heath Refining Company, Gladewater, Texas, has completed a 2500-barrel crude skimming plant in the Camps Switch section of the East Texas field, with tank car loading facilities on the Texas & Pacific Railroad.

Refinery: Lion Oil Refining Company is reported planning erection of a

For Your Receiving House

OCECO

CYLINDRICAL LOOK BOXES

Made in 3"—4"—6" sizes of tough heat resisting glass cylinders, providing plenty of light and a *good view always.*

Write for Information

THE JOHNSTON & JENNINGS COMPANY

Oceco Division

877 ADDISON ROAD CLEVELAND, OHIO

MADE WELL
BECAUSE THEY'RE
DROP-FORGED
by
WILLIAMS

"VULCAN BOLL-WEEVIL" REVERSIBLE TONGS

A fast tong for horizontal pipe work, excellent for all-around use. REVERSIBLE ACTION — "makes up" or "breaks out" without removal from the pipe—*without even unhooking the chain!* Jaws cannot spread. Unique handle design provides extreme rigidity — maximum strength. Only 6 parts. Four sizes for ¾" to 12" pipe.

SUPERIOR DROP-FORGED WRENCHES

Superior tools with 50 years of wrench-building behind them. Tough, strong jaws with accurately milled openings. Drop-forged from a special grade of carbon steel. 50 patterns in more than 1000 sizes guarantee the right wrench for every oil-field need—a wrench that will stand the gaff!

Buy from your distributor

J. H. WILLIAMS & CO.
"The Drop-Forging People"
75 SPRING ST., NEW YORK
Western Warehouse and Sales Office: Chicago
Works: Buffalo, N. Y.

WILLIAMS
SUPERIOR DROP-FORGED TOOLS

refinery at Dinero, Live Oak County, Texas, near the McNeill field, in which it is a major lease holder. Oil produced from the field mentioned and two others within four miles of the proposed site ranges in gravity from 44 to 52 A.P.I.

Refinery: Pickett, Pickett and Pickett, Whitsett, Live Oak County, Texas, are reported planning erection of a plant to produce fuel oils and Diesel oils from nearby Jacob field crude.

Terminal: Independent Refiners Marketing Corporation, formed in March of this year by several East Texas refining concerns, is making necessary changes to utilize the old Pierce Oil Corporation refinery at Texas City, Texas, as a shipping terminal for crude and refined products. It is further reported that the corporation plans a pipe line from East Texas and the ultimate building of a large modern refinery on the old plant site.

Solvent Dewaxing: Herbert Green & Company, Ltd., East Halton, Lincolnshire, England, now completing installation of a Duo-Sol solvent refining plant, has secured license from Texaco Development Corporation covering installation of an acetone-benzol plant for dewaxing.

Refinery: Cooperative Consumers Refinery, Inc., Wichita Falls, Texas, has been formed to take over and operate Arthur Refining Company's 1500-barrel skimming plant at Megargel, Texas. Organizers are W. C. Duncan, James H. White and G. M. Howard, owners of producing properties from which crude supply is secured.

Chemical Plant: The Carbide & Carbon Chemicals Corporation has announced completion of its $10,000,000 new chemical plant at Whiting, Indiana, where it is manufacturing chemical products from the waste gases of the nearby refinery of Standard Oil Company (Indiana). Permit has been issued for the manufacture of ethyl alcohol.

Bottle Gas Plant: Gas & Oil Products Company, Inc., Philadelphia, John H. Ware, president, is building a large liquefied petroleum gases plant in Clarion County, Pennsylvania, on the site of the old refinery at Lucinda. Construction and engineering contract to Burrell-Mase Engineering Company, Pittsburgh.

Resume: United Oil & Refining Company, (Sunflower Refinery Corporation), Hutchinson, Kansas, is reported planning to resume operations in May after being shut down one year.

Operating: Sabine Valley Gasoline Company has completed construction of its new East Texas natural gasoline plant between Kilgore and Longview, and is to begin operating in May.

Refinery: Wilshire Oil Company at Santa Fe Springs, California, has given contract to Ralph M. Pardons Company for construction of its 12,500-barrel plant. Contract includes working tanks, boilers, fire protection installation, electric power plant, sewer system with oil trap, oil transfer and yard pipe system, water circulation and cooling system, office, warehouse and shop, in addition to the latest type Dubbs cracking unit of 8000 barrels daily charging capacity.

Dismantling: Continental Oil Company, Ponca City, Oklahoma, has disposed of its Sapulpa, Oklahoma, refinery to Brown-Strauss Corporation, Kansas City. Equipment at this skimming and cracking plant will be dismantled and sold by the new owners.

Shut Down: Signal Gasoline Company of Texas has suspended operations at its Big Lake, Texas, natural gasoline plant. Plant has been operating since 1926 but available supply of gas has declined to less than 3,000,000 feet. Big Lake Oil Company is operating two plants in the area on gas produced by the deeper wells in the field.

Operating: McClanahan Refineries, Inc., Mount Pleasant, Michigan, has placed in operation its 1500-barrel daily capacity skimming plant near Saint Louis, Michigan. C. C. McClanahan is president of the company. Construction work was handled by H. P. Bostaph, Fort Worth, Texas, consulting engineer.

Refinery: Dent Refineries, Ltd., Vancouver, British Columbia, Canada, will build a $250,000 refinery on a 40-acre site on Burrard Inlet. The project is backed largely by United States capital.

Refinery: Inland Refineries, Inc., Drayton Plains, Oakland County, Michigan, plans erection of a skimming plant to be erected and operated under the direction of E. G. Guy, consulting engineer.

Refinery: Pentagon Refining Company is building a 1500-barrel skimming plant at Plymouth, near Detroit, Michigan.

▼ BUSINESS NOTES ▼

AS a result of increased activity in its Diesel and gas engine lines, the Worthington Pump and Machinery Corporation has found it advisable to further amplify the supervision of business in these lines in its eastern district—and to that end has created the Eastern Oil Power Division under the field management of Ray L. Howes, with headquarters at its New York office, 2 Park Avenue. Mr. Howes is widely known in the Diesel engine world and has had extensive experience in its various fields of application.

DIRECTORS of Blaw-Knox Company, at the recent organization meeting, created the office of chairman of the board. Albert C. Lehman, president, was elected to the new post in appreciation of his 30 years of service to the company since its inception, a resolution of the board stated.

Irvin F. Lehman, vice president, who has also been associated with the company since its early days, was elected president, and Frank Cordes was made senior vice president.

The following were re-elected: Chester H. Lehman, vice president; Robert F. McCloskey, vice president; George L. Dumbauld, treasurer; H. B. Loxterman, secretary; B. L. Hirshfield, chairman finance committee; Paul W. Keim, assistant treasurer; H. S. Strassburger, assistant treasurer and assistant secretary; P. A. McCullough, comptroller.

After May 1, the address of Turbo-Mixer Corporation, specializing in mixing and agitating equipment, will be 247 Park Avenue, New York, N. Y.

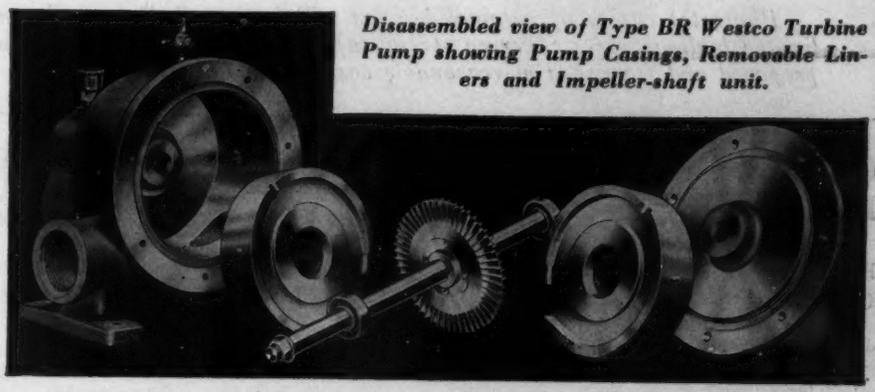
ANNOUNCEMENT has been made of appointment of The Foxboro Company as distributors of "Commercial" Orifice Fittings, made by Commercial Iron Works of Los Angeles. It is believed that the broad facilities for trained engineering service offered by The Foxboro Company will aid users to apply the fittings more successfully, in addition to the obvious advantages of securing undivided responsibility for an entire metering set-up.

Maintenance Engineering Company, Houston, represents Commercial Iron Works in Texas, and The Foxboro Company connection applies elsewhere in the United States.

MEXICO Refractories Company of Mexico, Missouri, have established sales representatives for the Texas, Oklahoma, Kansas and Missouri territories and a portion of Arkansas. C. W. Harrington is district representative at 318 Thompson building in Tulsa. He covers the Oklahoma and Arkansas areas. C. N. Eubank is district representative in the Dwight building in Kansas City, covering the Kansas and a part of the Missouri territory, and Harry Sharp at 2405 South Harvard, Dallas, is covering the Texas territory for the company.

Correction

IN the article "Technical Control of Percolation Filtration," Part 2, Refiner, issue of April, 1935, page 168, immediately following the sub-title "Standard Method of Running Filters" the following statement appears, "Pennsylvania cylinder stock solution should be filtered at 350°F." This is obviously incorrect and the sentence should read "Pennsylvania cylinder stock solution should be filtered at 135°F."



Disassembled view of Type BR Westco Turbine Pump showing Pump Casings, Removable Liners and Impeller-shaft unit.

NEW PUMP IMPROVEMENT
saves money for WESTCO users

Patented, Removable Liners enable Westco to again lead the way in pump design

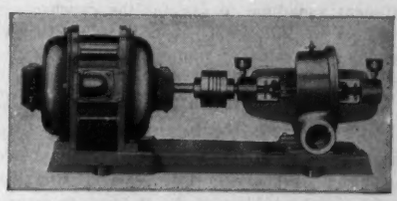
REMOVABLE LINERS are simply a complete lining for Westco Pump casings. They form the liquid channel and are quickly and easily removed from the casings. The money-saving advantages of this valuable feature are:

1. *Lifetime service from pump casings*
2. *Less metal required for alloy construction*
3. *"Stand-by" pump protection available at about 1/10 usual cost*
4. *Capacity of pump can be increased or decreased*

Superior Construction

Westco Turbine Pumps have a double-suction intake which creates a perfect hydraulic balance. Ingenious design of vertically split casing permits easy removal of Liners, Impeller-shaft unit and bearings (complete disassembly) without disturbing suction or discharge connections.

These pumps are favorites throughout the industry for Still Charging, and for handling Hot Oil, Fullers Earth, Chlorine Treating Solutions, Mineral Seal Oils, Naphtha, Chemicals, Brine, Water, etc.



Type BR Westco Turbine Pump

Send Coupon for Details

Send coupon below for FREE interesting literature and handy Performance and Selection Tables. No obligation. WESTCO PUMP CORPORATION, Davenport, Iowa. Branches: New York, Phila., Chicago, Los Angeles and San Francisco. Representatives in 50 Principal Cities.

—COUPON BRINGS DETAILS—

WESTCO PUMP CORP., Davenport, Iowa. Dept. N-5. *Gentlemen: Without obligation please send me Form 679 and Tables.*

Name .....
Address .....
City .....
State .....

WESTCO TURBINE PUMPS
HIGH PRESSURE — SINGLE STAGE

SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Chemical Composition and Reactions

The Mineral Content of Petroleum. E. LONGOBARDI. *Jour. Inst. Pet. Tech.* **21** (1935), pp. 132-4.

The inorganic components of petroleum are discussed, particularly vanadium. Up to the year 1913 the known inorganic components comprised the elements silicon, arsenic, phosphorus, aluminum, iron, calcium, magnesium, copper, silver, gold, vanadium, and sodium. This list has now been increased by the addition of titanium, lead, tin, nickel, manganese, chromium, barium, strontium, potassium and lithium. Vanadium is found in too great proportions in lignites, shales, and natural asphalts to be explained merely by its wide distribution in nature. If it can be proved that vanadium is present in petroleum to a greater extent than could be due to mere coincidence, it will evidently be associated with peculiar types of substances and form a link between them. This is illustrated with reference to the mineral rafaelite and the crude petroleum from San Rafael in the Argentine. The flue dust of oil burning tank ships has been collected and utilized in British steelworks. It contains sufficient vanadium to pay for the expense necessary to its utilization. San Rafael petroleum contains 45 grams of vanadium pentoxide per ton.

Thermal Reactions of Benzene. F. C. MEAD, JR., AND R. E. BURK. *Ind. Eng. Chem.* **27** (1935), pp. 299-301.

A brief review of the technical literature bearing on the subject of the thermal decomposition of benzene is first given. The apparatus used by the authors and the data secured by its use are presented. The conclusion was reached that the thermal decomposition of benzene in quartz is, under the conditions investigated, a heterogenous, bimolecular reaction that is strongly retarded by the adsorption of products on the surface of the reaction vessel. Steel also was found to catalyze the reaction. The plot of log k vs. 1/T gives a straight line, the slope of which corresponds to an apparent energy of activation of 50,000 calories. The products of the reaction are hydrogen, acetylene, a small amount of other unsaturated gases, methane, diphenyl, para-diphenylbenzene, and a small amount of other higher condensation products of benzene. The ratio of the weight of gases formed to the weight of solids formed decreases with increasing partial pressure of benzene at any given temperature.

Properties of 1-Octadecane, n-Octadecane, and Di-m-tolyl-ethane. M. V. DOVER AND W. A. HENSLEY. *Ind. Eng. Chem.* 27 (1935), pp. 337-9.

The purpose of the investigation was to synthesize a few hydrocarbons, the properties of which would resemble those of lubricating oils of low viscosity, and secondly, to study the chemical and physical properties of the hydrocarbons prepared in an effort to determine whether any of these properties are related to oiliness. 1-Octadecene was prepared by decomposing octadecyl stearate. n-Octadecane was prepared by hydrogenating 1-octadecene. Di-m-tolylethane was prepared by the oxidation of m-xylene with potassium persulfate. Molecular refractivity, iodine number, surface tension, interfacial tension, specific gravity and refractive index, viscosity and coefficients of dynamic friction were determined and are tabulated. The difference between the coefficient of friction of 1-octadecene (0.106) and n-octadecane (0.096) indicates that unsaturation is not an important factor in determining oiliness. However, the coefficient of friction of di-m-tolylethane (0.230) is much higher and indicates that the diphenyl substituted paraffins are deficient in oiliness. No indication was found that any physical property is directly related to the property of oiliness. However, there is a parallel between the dielectric constant and the coefficient of friction.

Contribution to the Subject of Chloroparaffins. R. STRAUSS. *Erdoel u. Teer* **11** (1935), p. 83.

Chloroparaffins are of interest because by replacing the chlorine with hydroxyl or aminol groups they are converted into commercially useful substances. The author describes the chlorination of a soft paraffin, of melting point 40-42°C., and also of a hard paraffin, melting point from 52-53°C. Chlorinated paraffins improve the solubility of castor oil in mineral oil, and this at temperatures that do not affect the castor oil.

Products: Properties and Utilization

Color Stability of Gasolines. G. EGLOFF, J. C. MORRELL, W. L. BENEDICT, AND C. WIRTH, III. *Ind. Eng. Chem.* **27** (1935), pp. 323-29.

The stabilization of the color of some motor fuels when exposed to direct sunlight is still a problem. In addition to drop in color, there is haze and in some cases sediment formation. Color stabilities of Pennsylvania and Mid-Continent gasolines were determined in a carbon arc lamp. Mercaptans when added to the gasolines have little effect on color stability, but sulfur and alkyl disulfides caused the development of color and haze. Sulfur was found to be more harmful to cracked than to straight-run gasolines, but disulfides were more detrimental to the straight-run gasolines. The color instability of Mid-Continent gasolines sweetened with sodium plumbite and sulfur was the result of excess sulfur and disulfides from the sweetening. Improved stability was had by removing either disulfides or sulfur, but complete stability was had only by removal of both. Fuller's earth treatment did not improve color stability. The color forming in straight-run gasolines was largely occasioned by suspended particles, but in cracked gasolines was largely soluble colored compounds.

Specifications for Lubricants. A. J. GENTIL. *Chem. Weekblad,* **41** (1934), p. 605.

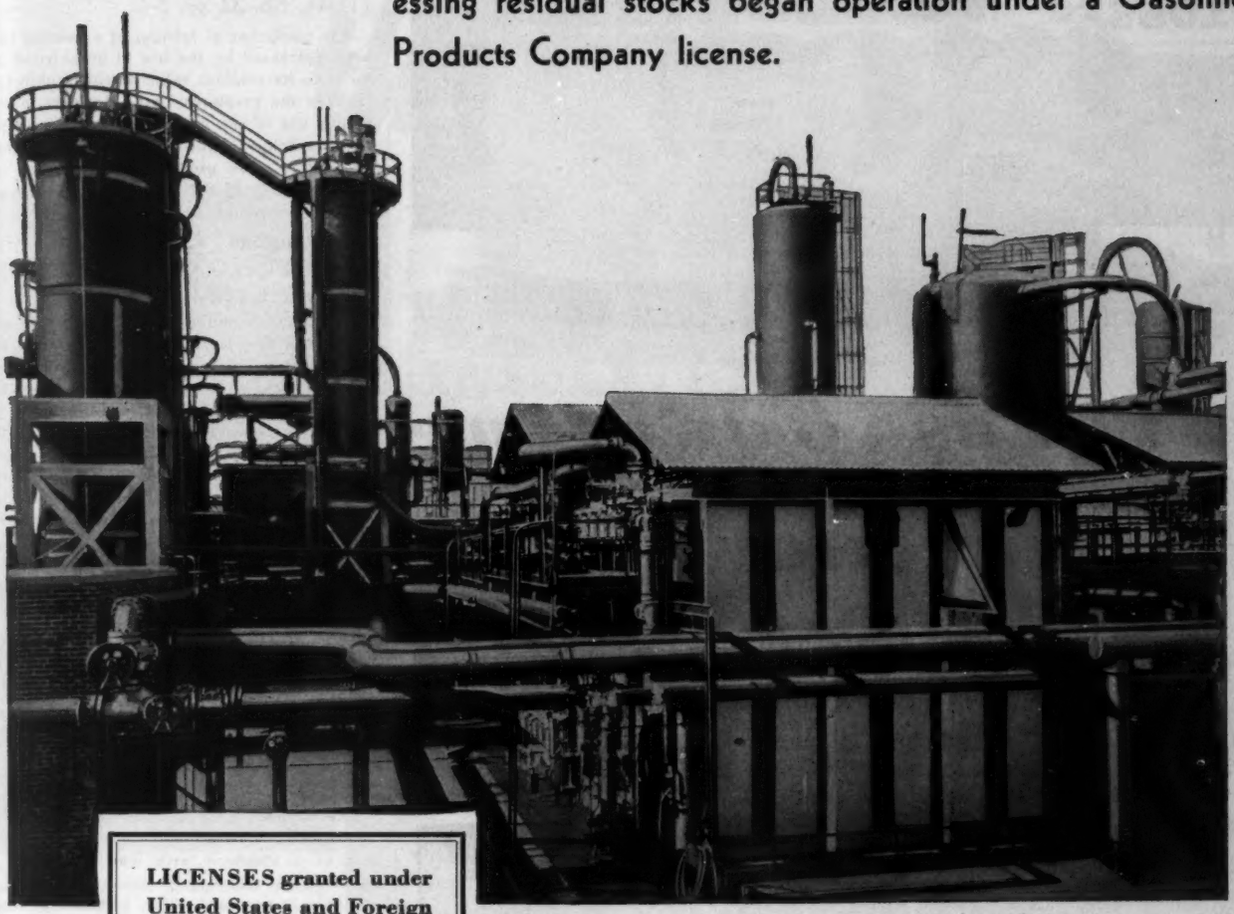
The measurement of viscosity at 210°F. is criticized for the working temperature range for cylinder oil is 210°F.-572°F. Ubbelohde viscosity measurements are more accurate. No method for the measurement of oiliness has been standardized. However, it is recognized that drastic refining removes those components that contribute to the greatest extent to oiliness. A small amount of ricinoleic acid will take the place of much larger quantities of fatty oils in the making of compound oils. A list for specifications for solid and semi-solid lubricants and greases is given.

A Survey of Lubricants Used in the Cotton and Woolen Industry. C. H. BAXLEY AND C. M. LARSON. *Textile Bull.* **47** No. 18 (1935), pp. 4-6, 20.

A survey of the lubricants used by 150 mills was made. The oils are grouped under the classifications: spindle oils, general-purpose oils, comb-box loom lubricants, power-house oils and steam cylinder oils. Data on viscosities at 100° and 210°F. were plotted on standard A.S.T.M. temperature-viscosity chart paper. The plots so prepared emphasized the necessity of knowing viscosities at two temperatures in order to understand the viscosity characteristics of any given oil. A table was prepared suggesting the various required textile oils with their recommended Saybolt Universal viscosity. The principal uses

... in CANADA

During 1934 a cracking unit of the latest design for processing residual stocks began operation under a Gasoline Products Company license.



LICENSES granted under United States and Foreign Patents for: Cross • de Florez • Holmes-Manley • Tube and Tank Cracking Processes and Combination Cracking Units.

Licensing Agents:
The M. W. KELLOGG CO.
225 Broadway · New York
or its
European Representative:
Compagnie Technique des Petroles · 134 Boulevard Haussmann · Paris, France

By coordinating the results of experiments, developments and operation of several major refinery organizations Gasoline Products Company is able to offer combination cracking units embodying those features of design adapted to the individual problems of the refiner.

This coordination of technical data assures the refiner that the designs available include the latest developments in cracking technique.

We suggest you investigate this comprehensive service before investing in cracking equipment.

GASOLINE PRODUCTS COMPANY

INCORPORATED

11 COMMERCE STREET · NEWARK, NEW JERSEY

Natural Gasoline
protected against EVAPORATION in Radial Cone Tanks

THE International Petroleum Company, Ltd., of Talara, Peru, stores natural gasoline of 23 pound Reid vapor pressure in two radial cone pressure tanks of 55,000 bbl. capacity.

The atmospheric temperature at Talara ranges from 65°F. to a maximum of 96°F. At these temperatures the internal tank pressures with 23 pound natural gasoline do not exceed 10 pounds, a condition which prompted the selection of radial cone tanks for its storage.

It was found that the actual internal tank pressure varies between 5 and 6 lbs. in the cooler season and is slightly higher during the summer. It is never high enough, however, to operate the relief valve set at 10 lbs., and cause evaporation loss.

The radial cone tank is one of the three types of pressure tanks which we build to stop evaporation loss, and is designed for internal pressures up to 10 lbs. The others are the Hortonspheroid for internal pressures up to 20 lbs., and the Hortonsphere for higher pressures. The Wiggins Pontoon Roof and the Wiggins Breather Roof, complete a line of storage units that eliminate tremendous evaporation losses.

Consult our engineers on your evaporation problems. Such action may be the first step toward a substantial reduction of evaporation loss and a very considerable financial saving. Write nearest office.

Other Equipment to Stop Evaporation

CHICAGO BRIDGE & IRON WORKS

Dallas.....1255 Dallas Athletic Club Bldg.
Houston.....2912 Main Street
Tulsa.....1626 Thompson Bldg.
Birmingham.....1548 Fiftieth Street, N.
Chicago.....2463 Old Colony Bldg.
Detroit.....1520 Lafayette Bldg.
Cleveland.....2234 Rockefeller Bldg.
New York.....3302-165 Broadway Bldg.
Philadelphia....1608-"1700" Walnut St. Bldg.
Boston.....1529 Consolidated Gas Bldg.
San Francisco.....1051 Rialto Bldg.
Los Angeles.....1334 Wm. Fox Bldg.

Plants in Chicago, Birmingham and Greenville, Pa.

of greases are given, and suggested textile greases with their soap bases and A.S.T.M. penetration are tabulated.

The Duration of the Action of Graphite in Lubricated Bearings. O. WALGER AND H. V. SCHROEDER. *Petroleum* 30 (1934), No. 32, pp. 2-4.

The coefficient of friction of a bearing that has been decreased by the use of graphitized oil, returns to its original value when graphite-free oil replaces the graphitized oil. However, after prolonged use of the graphitized oil, the coefficient remains below its original value when graphite-free oil is again used, but the decrease is only approximately 25-33% of the reduction produced by the continuous use of graphited oil.

Bituminous Coatings for Underground Pipes. G. O. THOMAS. *J. Inst. Eng. Australia,* 6 (1934), pp. 337-346.

Testing of bituminous materials to be used as pipe coverings is discussed. Standard methods are given, as well as other methods to obtain data not secured from the standard methods. The results as given were obtained during a period of four years work on the subject in the laboratory, in the plant, and in the field. The pipes considered were steel water-mains that were factory-coated. Coal-tars and their pitches, together with the coal-tar base enamels, were proved to be outstandingly the best water-resistants. Vertical retort tar is considerably inferior to horizontal retort or coke-oven tar. Horizontal retort coal-tar pitch exceeds all other common bituminous material in its resistance to water and permanent adhesion to steel.

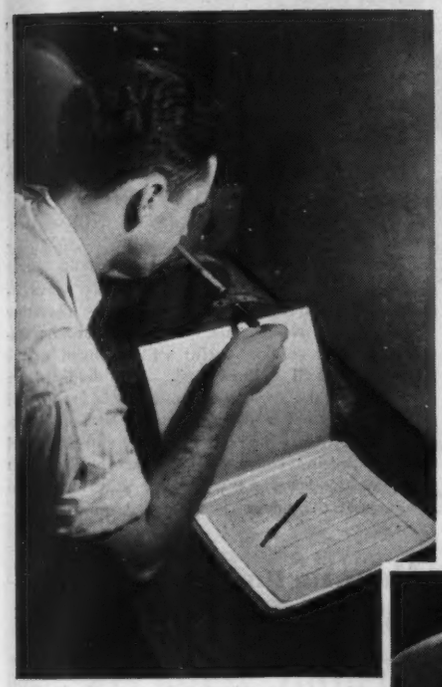
A Pure Hydrocarbon Standard for Evaluating Inhibitors. C. G. DRYER, C. D. LOWRY, JR., G. EGLOFF, AND J. C. MORRELL. *Ind. Eng. Chem.* 27 (1935), pp. 315-17.

The authors note that research on gasoline antioxidants has been handicapped on account of lack of a standard with which to make comparisons. A reproducible means of rating antioxidants is proposed. This is based on the use of a pure hydrocarbon. After testing a number of different hydrocarbons, cyclohexene was selected as a base material for inhibitor valuation. As a measure of inhibiting value the cyclohexene number is proposed. This is the number of minutes which the induction period of cyclohexene would be increased by the additiona of 0.002% of the inhibitor as calculated from tests made in reference gasoline whose relationship to cyclohexene has been determined by standardization with alpha-naphthol. Cyclohexene numbers are given for 41 representative inhibitors.

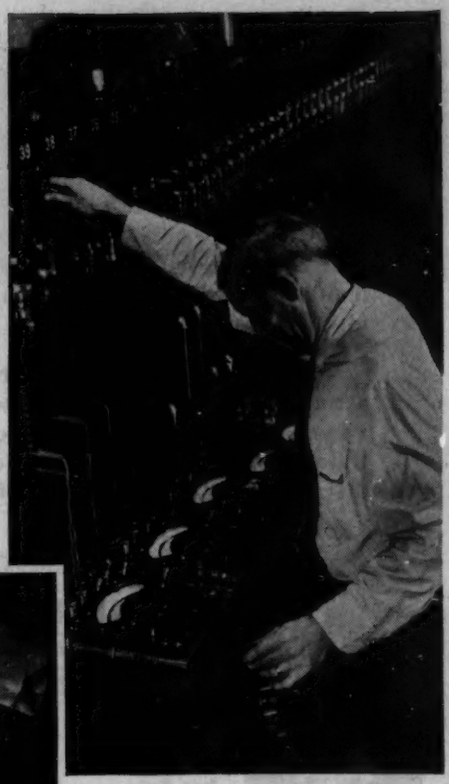
Determination of Mercaptans in Hydrocarbon Solvents. W. M. MALISOFF AND C. E. ANDING, JR. *Ind. Eng. Chem., Anal. Ed.,* 7 (1935), pp. 86-8.

The authors note that the method of Borgstrom and Reid for determining mercaptans is subject to some difficulty in use. An effort has therefore been made to establish safeguards and a sharper definition of conditions in order to insure a higher degree of reproducibility. It is noted that mercaptans, especially the aromatic ones, change readily to disulfides by oxidation. Exposure to direct ordinary daylight will cause disappearance of all of certain mercaptans in a hydrocarbon solution originally containing 0.3% mercaptan sulfur. Prolonged storage in a laboratory cabinet with glass doors but no direct sunlight results in serious changes; thus short storage in the dark is necessary. Other changes in Borgstrom and Reid procedure involve adoption of a uniform dilution method, employment of a more dilute standard solution, standardization of the ferric alum indicator, provisions for minimizing emulsions, provision for minimizing making

Guardians of the B.t.u.



Johns-Manville
INDUSTRIAL INSULATIONS
For every temperature condition from 400° F. below zero to 3000° F. above.



(Right) Switchboard that controls the power supplied to the heaters in conductivity testing units at the J-M Insulation Laboratories. Power input to any heater may be measured to within ½ of 1 per cent.

(Above) A split hair at furnace heat! Measuring with a micrometer gauge the thermal changes of a high-temperature insulation material. Furnace at left containing test specimen is accurately controlled. Expansion or contraction at high temperatures must be fully understood before recommendations for specific installations are given.

(Left) Measuring and evaluating dried test specimens of insulating cements at the J-M Insulation Laboratories. The same weight of material was employed for both specimens. Note high shrinkage of the one in the foreground.

IN THESE photographs, in these brief captions, we can give you no more than a few hasty glimpses into our Thermal Insulation Laboratories, at Manville, N. J., largest in the world.

But we hope that you will come right into the laboratories with us, through the medium of our new brochure, entitled "Guardians of the B.t.u."

Here, in highly realistic photographs and interesting text, there is unfolded the fascinating story of many men who are devoting their lives to the study of one subject... the *control of heat.*

Their equipment, their experiments, their tests, cannot fail to be of interest to any technical man.

And, if your interest in the subject is a more practical one, if you are concerned with the more efficient, more economical operation of any type of heated or refrigerated equipment, you literally cannot afford to ignore the importance of heat-control research as it is carried on daily at Manville... research which has resulted in savings to industry totaling hundreds of millions of dollars annually.

For your copy of "Guardians of the B.t.u.," please fill in and mail the coupon. Johns-Manville, New York City.

(Right) A recent J-M Insulation Laboratory development, this "heat eye" permits measurements of surface brightness, emissivity of heat from surfaces, etc.

JOHNS-MANVILLE, 22 East 40th St., New York City

Send me a copy of "Guardians of the B.t.u."

Name_____

Address_____

City_____ State_____

RNG-5-35

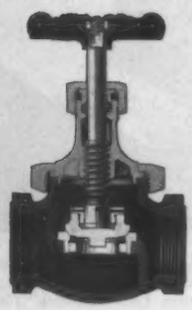
Keep Down the Cost of Upkeep

Lunkenheimer Interchangeability of Parts Reduces Maintenance Expense

An important maintenance item which you can't afford to overlook in effecting plant economies is the interchangeability of parts between Lunkenheimer Full-Way and Plug Type "Ferrenewo" and "Renewo" Valves.

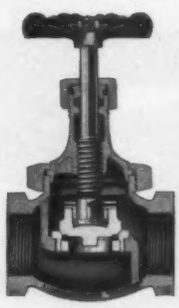
All parts of the Full-Way type interchange readily with the new "NS5" Plug Type in both the "Ferrenewo" and the "Renewo". This means that only *one* stock of parts is necessary for these four types of valves—150 lb. Iron Body "Ferrenewo" and 200 lb. Bronze "Renewo" (Full-Way and Plug Types)—and that repairs are facilitated, ordering and handling are simplified, resulting in low maintenance cost and ultimate low valve cost.

Have your Lunkenheimer distributor demonstrate with actual samples the flexible interchangeability between these valves. "Ferrenewo" and "Renewo" Valves are fully illustrated and described in the new booklet F541. Ask your distributor for a copy or write for one direct.



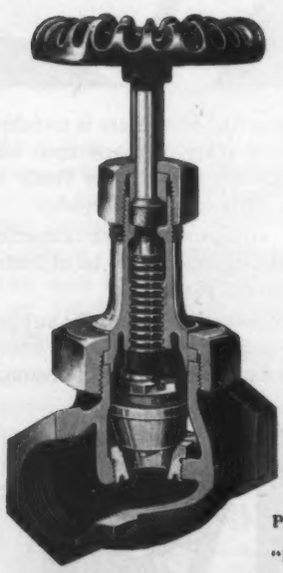
Full-Way Iron Body "Ferrenewo"

THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO BOSTON
PHILADELPHIA SAN FRANCISCO
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK



Full-Way Bronze "Renewo"

Plug Type Iron Body "Ferrenewo"



Plug Type Bronze "Renewo"

BOILER MOUNTINGS — LUNKENHEIMER VALVES — LUBRICATING DEVICES

102-74-89

of color, and reduction of the time of operation. Data are cited to show the improvement resulting from attention to these various matters.

Extinction Coefficients of Mineral Lubricating Oils. R. KOETSCHAU. *Brennstoff-Chem.*, **15** (1934), pp. 441-449.

The Pulfrich photometer was used in examining mineral lubricating oils in the determination of the extinction coefficient as a function of the wave length of the light used. The effect of bleaching the oil by means of earth, of changes occurring on heating for various periods at 120°C., of changes upon use in the engine, the effect of the extraction of oils with nitrobenzene, all can be shown quantitatively by determining the extinction coefficient curve. The method can also be used in the study of motor gasolines by determining the extinction coefficient for violet light. Other applications of the method are discussed.

Direct Determination of the Total Oxygen in Oils. M. E. MARKS. *Ind. Eng. Chem., Anal. Ed.*, **7** (1935), pp. 102-3.

The problem involved in the direct determination of oxygen in oxidized oils is one of finding a satisfactory method that takes care of sulfur and nitrogen. Crude oils contain as much as 2% to 3% of sulfur and nitrogen. On the other hand, highly refined oils, such as cable and transformer oils, contain sulfur and nitrogen to the extent of well below 0.1%. The modified ter Meulen method involves passing the vapors of the organic substance in an atmosphere of hydrogen over an active thoria-promoted nickel catalyst, using calcium sulfate as the absorbent for water. Data are presented showing the accuracy of the method.

Manufacture: Processes and Plant

Entrainment in Plate Columns. T. K. SHERWOOD AND F. J. JENNY. *Ind. Eng. Chem.* **27** (1935), pp. 265-72.

The authors comment upon the importance of allowable vapor velocities in determining the diameter of fractionating columns. Vapor velocity may be limited by the excessive pressure drop across each plate at high vapor velocity and the danger of priming, and further, by the entrainment of liquid from one plate to the next. Previous work is reviewed. The equipment used in the experimental work is described and the data presented. These data cover an experimental study of the effect of various factors on the entrainment of water by air in a bubble-cap column, and second, a study of the relationship between entrainment and column performance, both for fractionation and for the separation of non-volatile impurities. The authors conclude that the importance of entrainment as a factor reducing the efficiency of rectifying columns has been overstressed and that the entrainment of less than 0.1 mol of liquid per mol of vapor is negligible in most ordinary cases. On this basis vapor velocities of 4 feet per second upward would be permissible in columns with 12-inch plate spacing. It appears probable that column capacity will be limited by pressure drop or priming rather than by entrainment.

The Determination of Plate Efficiency in Fractionating Columns for Complex Mixtures. A. J. V. UNDERWOOD. *Jour. Inst. Pet. Tech.* **21** (1935), pp. 125-31.

The author stresses the importance of knowing the efficiency of fractionating plates, which ordinarily is taken as the ratio of the change in composition of the vapor effected by the plates to the change in composition that would result

You can take the gumbugs out of cracked gasoline with sulfuric acid but you take out antiknock value at the same time and some of the gasoline too Unsaturated hydro-carbon molecules gang up with oxygen molecules from the air and turn into gum-bugs—if they get a chance

Universal Liquid Inhibitor is a chemical cop that keeps the gumbugs from forming—saves all the antiknock value and all the gasoline

And saves acid cost

If you would like to know what Universal Liquid Inhibitor will do for you, just send us samples of your cracked gasoline The sooner you do, the sooner you can forget your gum troubles

Universal Oil Products Co
Chicago Illinois

Dubbs Cracking Process
Owner and Licensor

Copyright 1935, Universal Oil Products Co

"Best Investment we've made in months!"

One prominent Texas refinery now cleans 17 tubes in the time formerly required to clean 5 tubes with the old type Lagonda Cleaners and drills. This saving in valuable time is due entirely to the improved design of both motors and cutter heads in the new 450 Series Lagonda Cleaners.

Put this increased tube cleaning speed to work for you. It quickly saves the first cost of the cleaning equipment, making tube cleaning time-out a much smaller item in tube still maintenance.

Write for the bulletin describing the latest developments in still tube cleaning.

X-1517

THE LAGONDA MANUFACTURING CO.
SPRINGFIELD, OHIO
An Elliott Company Organization • District Offices in Principal Cities

if the vapor after passing through the plates were in equilibrium with the liquid upon the plates. It is sufficient to know the liquid composition upon the various plates of the column. The vapor compositions can be calculated from the liquid compositions by the use of material and thermal balances.

New Design Calculation for Multi-Component Rectification. E. R. GILLILAND. *Ind Eng. Chem.* **27** (1935), pp. 260-65.

Various methods for the design of a fractionating column for the handling of multi-component mixtures are reviewed and a new method is proposed. This is based on the use of the relative volatility and relative operability of the components in the mixture. The author states that the procedure is rapid and simple, and for the condition of infinite reflux the calculation reduces to Underwood's modification of Fenske's relative volatility system. For those instances in which separation between components is not relatively complete, the determination of the design by previous methods has been tedious. The author states that the proposed procedure offers a method facilitating such calculations. The application of the proposed procedure is illustrated by applying it to specific problems.

Distillation and Absorption in Packed Columns. T. H. CHILTON AND A. P. COLBURN. *Ind. Eng. Chem.* **27** (1935), pp. 255-60.

The authors describe a method for the design of packed columns and for the correlation of experimental data secured by the use of such columns. The procedure is based on the conception of a transfer unit which for distillation is defined as

$$\int_{p_1}^{p_2} \frac{dp}{\Delta p}$$

For gas absorption the transfer unit is defined as

$$\int_{p_1}^{p_2} \frac{dp}{\Delta p}\left(\frac{p_{gf}}{p_g}\right)$$

To compare the efficiencies of two columns it is only necessary to compare the height of a transfer unit in each of them. For many cases of distillation, the H.T.U. (height of transfer unit) and the H.E.T.P. formerly used are nearly identical. However, large distances between them exist for certain gas absorption problems. In a packed column ascending vapor and descending liquid are in contact and there is a diffusion of the lower boiling component from the liquid surface and of the higher boiling component to the liquid surface. Composition changes occur in a differential manner. The concept of the transfer unit takes into account the mechanism of the process. To make convenient the calculation of the necessary height of any given column the conception of the H.T.U. is introduced.

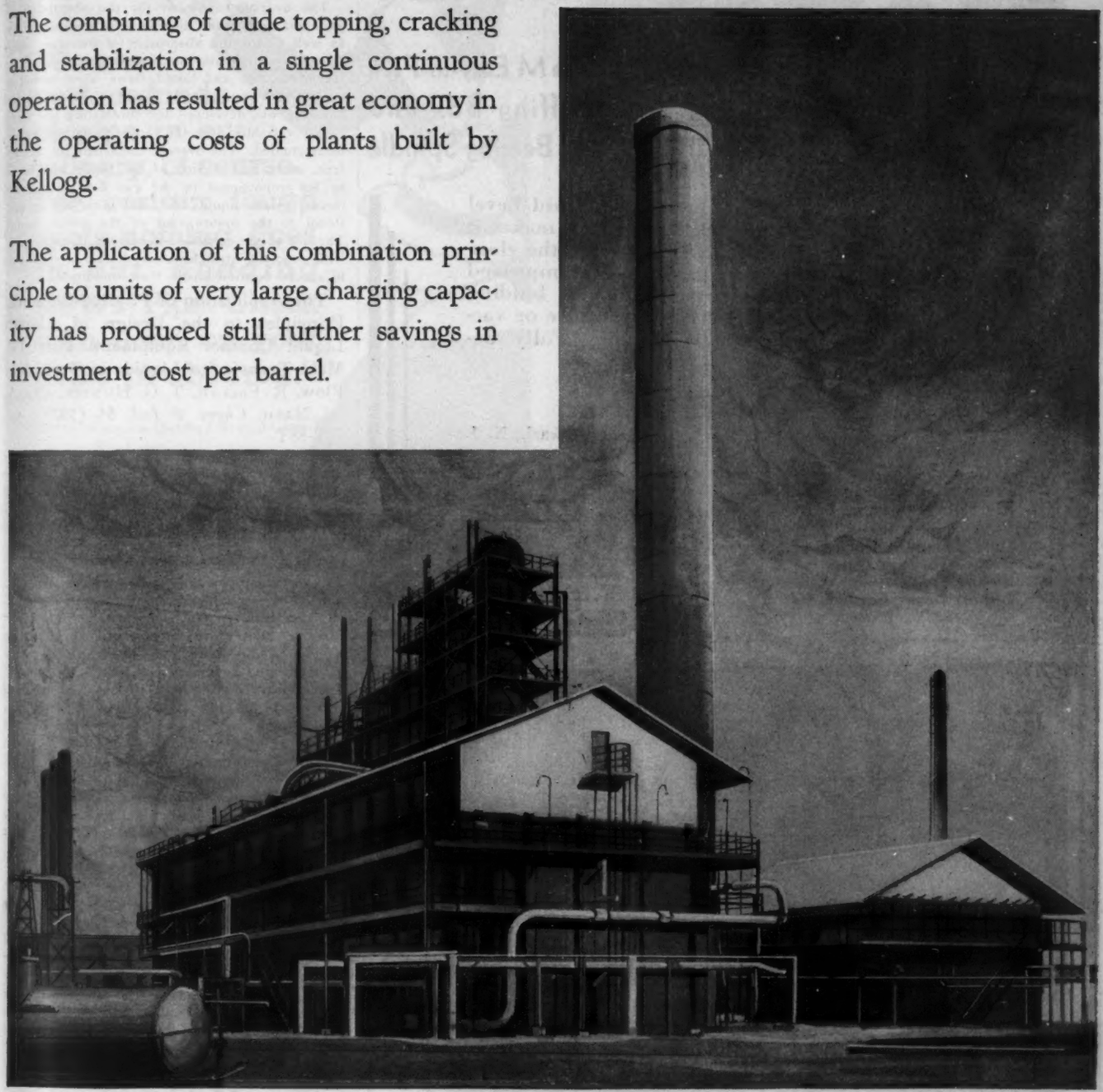
Absorption. A NEWTON. *Jour. Inst. Pet. Tech.* **21** (1935), pp. 75-88.

The author discusses the two processes for recovering gasoline or benzol from gases, namely charcoal absorption and oil absorption. The author's discussion is directed toward the principles of these processes and, more particularly, to certain experiences connected with their application. In the charcoal process sulfur and polymeric gum deposit upon the charcoal and slowly impair its activity. In the recovery of benzol from coal gas this involves a consumption of 7 pounds or more of charcoal per 1000 pounds of benzol produced. In natural gasoline practice not more than 1 pound per 1000 pounds is required, nor more than 3 pounds per 1000 pounds if the gas contains appreciable quantities

Operating and investment costs are lowered by large combination cracking units

The combining of crude topping, cracking and stabilization in a single continuous operation has resulted in great economy in the operating costs of plants built by Kellogg.

The application of this combination principle to units of very large charging capacity has produced still further savings in investment cost per barrel.



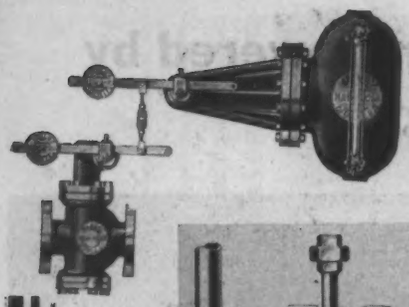
KELLOGG

THE M. W. KELLOGG COMPANY · 225 BROADWAY, NEW YORK

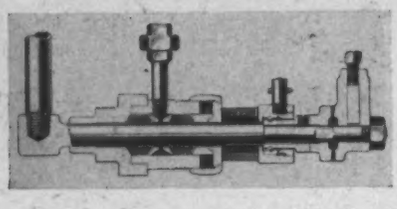
Los Angeles: 1031 South Broadway • San Francisco: 200 Bush Street • Tulsa: Philtower Building

Kellogg Products include: Cross, Holmes-Manley, de Florez and Tube and Tank Cracking Units. Absorption Plants and Pipe Stills. Deasphalting, Dewaxing, Solvent Extraction and Acid Treating Plants. de Florez Temperature Control. Pressure Vessels for the Power, Refinery and Chemical Industries. Power Plant and Industrial Piping. Pacific Hot Oil Pumps. Radial Brick Chimneys. Plastic Refractories.

Licensing Agent for Gasoline Products Company, Inc. Licenses granted under United States and Foreign Patents for: Cross · de Florez · Holmes-Manley · Tube and Tank Cracking Processes and Combination Cracking Units · · · · European Representatives: Compagnie Technique des Petroles · 134 Boulevard Haussman, Paris, France · · · · · ·



An Exclusive K AND M Feature



K AND M Easy-to-Pack Stuffing Box and Ball Bearing Spindle

An integral part of all K and M Liquid Level Controllers. Special stuffing box design makes it possible to slide complete assembly into the clear and reach the entire packing surface. Improved external ball bearing design eliminates binding and uneven wear. Ideal for high pressure or vacuum; safe for inflammable liquids. Fully described in Bulletin C-5.

KIELEY & MUELLER, Inc.

34 W. 13th St., New York, N. Y. *Plant:* Newark, N. J.

Pressure Regulating Valves
Air Pilot Operated Valves
Balanced Valves
Back Pressure Valves
Pump Governors
Steam Traps
Liquid Level Controllers

K and M

PRESSURE AND FLOW CONTROL APPARATUS

ON GUARD

A line carrying natural gas from the field to a large oil-company plant delivers the gas at an even pressure, in all weathers and at all seasons, because Fulton Regulators are on guard. Nothing unusual! Our illustration is like the picture of a sentry on guard, doing methodically what he has been trained to do well. Fulton Regulators have been serving all the requirements of pressure control, in the gas industry and elsewhere, for fifty years.

The Chaplin-Fulton Manufacturing Co.

28-40 Penn Avenue Pittsburgh, Pa.

of sulfur. In the discussion of the oil absorption process, particular attention is paid to the formation of sludge or muck in the circulating oil.

Absorption of Gases in Spray Towers. A. W. HIXON AND C. E. SCOTT. *Ind. Eng. Chem.* **27** (1935), pp. 307-14.

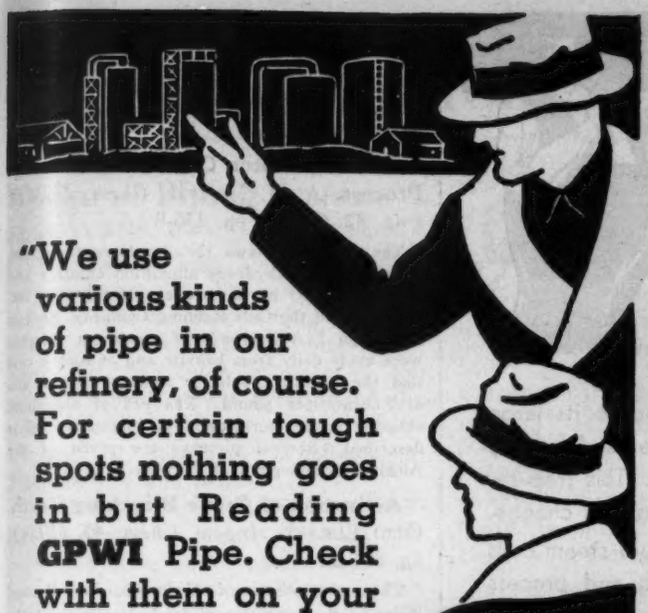
The over-all coefficient for the absorption of ammonia and sulfur dioxide into a water spray, as well as for the absorption of benzene vapor from an air stream into an oil spray, were determined. Gas and liquid flows were varied at several different tower heights. An empirical equation was developed for correlating the effect of the variables over the range of various conditions studied. The over-all coefficient for a wall-free, inner core section of the tower was found to be proportional to the gas flow to the 0.8 power, to the liquid flow, and inversely proportional to the square root of the tower height. The use of the equations developed in connection with practical straight-tower design is discussed in special relationship to their limitations.

The Application of Physico-Chemical Principles to the Design of Liquid-Liquid Contact Equipment. Part IV. Mass Transfer to Liquids in Turbulent Flow. R. FALLAH, T. G. HUNTER, AND A. W. NASH. *Chem. & Ind.* **54** (1935), pp. 49T-58T.

This paper is a continuation of two previous communications dealing with the fundamental principles underlying the design of equipment for the contacting of two liquids. The present paper describes an experimental investigation of the problem, as well as the effort to correlate the results in the light of the theoretical principles. The particular problem investigated was the variation of the individual liquid film extraction coefficients with dynamic condition, giving rise to turbulent flow of the two immiscible liquids in a double-liquid wetted-wall tower. In this type of contacting tower a thin film of one liquid flows downwardly over all of the available wall area, while the second liquid flows upward as a central core completely surrounded by the film of the wall liquid which separates the central core of liquid from the pipe wall. The system chosen for investigation was water-kerosene-phenol. The apparatus and test procedure are described in some detail. A comparison of the expressions for liquid film mass transfer coefficients with existing expressions for gas film mass transfer coefficients, and with heat transfer film coefficients, shows that the heat and mass transfer coefficients for fluids in turbulent flow, through cross-sections of circular shape, are all given by closely similar expressions. The constants in the mass transfer film and heat transfer film coefficient equations are of the same order of magnitude. However, the constant in the expression for the liquid film coefficient has a much greater value. This must be investigated further.

Sweetening of Gasoline with Alcoholic Alkali and Sulfur. B. A. STAGNER, *Ind. Eng. Chem.* **27** (1935), pp. 275-7.

The author proposes the use of a sweetening process involving the brief agitation of the gasoline with small quantities of elementary sulfur and a solution of caustic soda in methanol. Conversely, a gasoline containing free sulfur should be refined by contacting it with another containing mercaptans. No lead is used in the process. However, as in the lead sweetening process, sulfur must be added in exactly the amount required to effect the oxidation of the mercaptans. The alcohol used is recovered. The alkaline by-product shows traces of sodium polysulfide, free caustic soda, and large quantities of sodium monosulfide and sodium thiosulfate. The loss of gasoline through emulsification that is character-



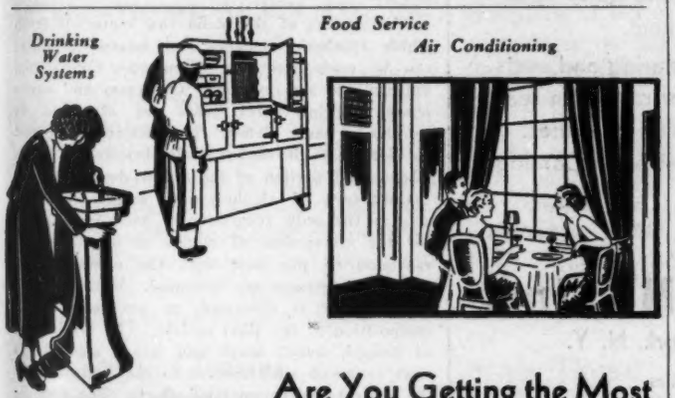
"We use various kinds of pipe in our refinery, of course. For certain tough spots nothing goes in but Reading **GPWI** Pipe. Check with them on your pipe problems."

*GPWI—Genuine Puddled Wrought Iron

For information, write

READING IRON COMPANY
PHILADELPHIA

SCIENCE AND INVENTION HAVE NEVER FOUND A SATISFACTORY SUBSTITUTE FOR GENUINE PUDDLED WROUGHT IRON



Laboratory Work

Process Work

Are You Getting the Most Out of Refrigeration?

Make your "ice machine" serve you in some of the additional ways here illustrated. By getting the most out of modern Refrigeration you can develop your prestige, trade and profits.

Let the nearest Frick man aid you in adapting Refrigeration to your wider problems. *Write, wire or 'phone today.*

Frick Company
WAYNESBORO, PA., U.S.A.
ICE MACHINERY SUPERIOR SINCE 1882

MANY a needless dollar is added to refinery operating costs when sulphuric acid and other corrosive liquids are improperly handled. LaBour Pumps earn their cost in a surprisingly short time because they are designed and built especially for acid work and are installed only after competent engineers have determined the exact requirements for the particular job.

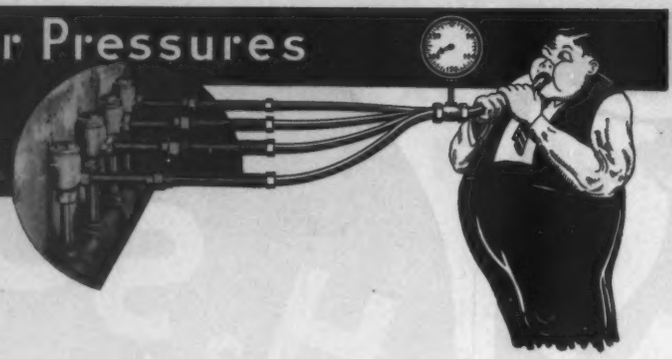
Throughout the process industries the name LaBOUR on a pump has come to mean operating economy, freedom from frequent shutdowns, and minimum maintenance costs. Our long and intimate contact with the problems of chemical operations has given us a vast fund of experience which is available to assist you in solving *your* problems.

We welcome an opportunity to show what LaBour Pumps can do for you, and to explain why, when *all* things are considered, these pumps are really the cheapest you can buy. There is no cost or obligation to you in asking us for details, which will be promptly supplied.

THE LABOUR COMPANY, INC.

507 STERLING AVE.
ELKHART, IND.

Now For Pressures up to 200 lbs.



To meet increasing pressures, Sarco has added to its large line of Steam Traps the Type 9-200 which can be used for any steady or fluctuating pressure from 0 to 200 lbs. This trap requires no adjustment in the field when steam pressures change.

It is especially adapted for draining high-pressure steam coils and jackets in connection with industrial heating and process work and for removing condensate from steam supply lines to all types of equipment.

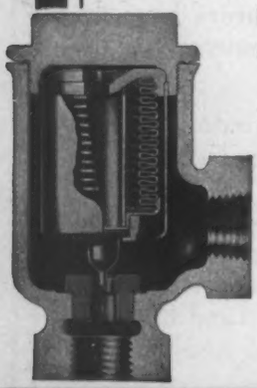
SARCO Steam Trap

has a hellically corrugated bellows of a design which assures long life under the most severe operating conditions. A patented shield protects element against water hammer and steam abrasion.

Spherical stainless steel valve head and seats and quick opening and closing reduce wire drawing to a minimum.

Patented lateral-moving valve head is self-centering and seats in any position. Valve head can rock or rotate on seat assuring an absolutely tight trap at high pressures.

Other outstanding features are explained in Catalog S-49. Write for a copy.



SARCO COMPANY, Inc.

183 Madison Ave., New York, N. Y.

Branches in Principal Cities

Sarco Canada Limited, Federal Bldg., Toronto, Ont.

WATER and AIR

A good steam trap should discharge both quickly. Nicholson does it quicker than majority of makes because it is a combination automatic air vent and water trap. Large in capacity and low in price. Vacuum to 200 lbs. 60 days trial. Bulletin No. 833 on request.

FLOATS

Stainless Steel and Welded Steel

(Chromium Plated)

For all pressures up to 2000 lbs. Round and oblong sizes 3″ to 12″ in diameter in stock. Inquiries on special floats solicited. Bulletin No. 431 on request.

W. H. NICHOLSON & CO. 157 Oregon St. WILKES-BARRE, PENNA.

istic of the ordinary plumbite sweetening procedure is not had in the proposed process. Costs of sweetening will be slightly over one-half cent a barrel, allowing no credit for by-products or for gasoline saved that otherwise would be lost by emulsification.

Refining Motor Oils by the Alchlor Process. A. M. McAfee. *Chem. & Met. Eng.* **42** (1935), pp. 136-8.

The author reviews the development of the technology of anhydrous aluminum chloride and the applications of this reagent at the Port Arthur plant of the Gulf Refining Company. Several years ago 75,000 pounds of aluminum chloride were made daily from bauxite and at such a cost that the material could be sold at carload lots at 5 cents per pound. The use of aluminum chloride in the purification of lubricating oil is described. Several pictures are given of the Alchlor process plant at Port Arthur.

Activation of Crude Bleaching Earth. Otto Eckart. *Angew. Chem.* **47** (1934), pp. 821-2.

The assumptions of Hofmann, Endell and Wilm on the activation of crude bleaching earths are not supported by the author's work. Activation cannot be accomplished by the formation of aluminic acid only. In the hydrochloric acid activation process aluminum oxide is dissolved with resultant increase of the active surface of the clay. Four bleaching earths were tested, using neutral soy oil, raw linseed oil, and sulfuric acid treated mineral oil. Earths activated by electro-dialysis were found to be no better than the crude earths.

Synthetic Alcohols and Related Products from Petroleum, I and II. B. T. Brooks. *Ind. Eng. Chem.* **27** (1935), pp. 278-88.

The sources of the olefin raw materials from which synthetic alcohols and related products can be made, are first discussed. Commercial experiments are reviewed. Oil gases and vapor phase cracking plant gases are discussed as sources of these olefins. The concentration and purification of the olefins is also briefly discussed. The second portion of the article deals with the manufacture of alcohols and esters. Sulfuric acid is the only reagent now used industrially for the conversion of olefins to alcohol. The reactions of this acid with the olefins under various conditions are reviewed. Hydrolysis of alkyl sulfate is discussed, as well as the decomposition of the alkyl sulfate. The production of propyl, butyl, amyl and hexyl alcohols is next reviewed with respect to the literature of the subject and commercial efforts. The production of esters, such as by the acetylation of the secondary alcohols, is briefly discussed. Bibliographies of twenty-eight references on the olefins and forty-six references on the olefin reactions and production of alcohols and esters are included.

Construction Materials for Petroleum Refinery Pumps. A. E. Harnsberger. *Chem. & Met. Eng.* **42** (1935), pp. 144-5.

The conditions of temperature, pressure, corrosion, and abrasion that refinery pumps must withstand are reviewed. The pumps are classified into the following groups: (1) general service pumps; (2) pumps for distillation and cracking equipment handling oils up to 200°F.; (3) pumps handling oils up to 900°F.; (4) pumps for gas absorption plants; (5) pumps for sludge acids; (6) pumps for treating processes. Reciprocating centrifugal and rotary pumps suitable for the various classes of service are discussed with reference to the type of material of which the various pump parts are made.

New Equipment for the Modern Plant

Design of Piping Systems

TUBE-TURNS, INC.

Tube-Turns, Inc., 745 South 5th Street, Louisville, Ky., recently published a new bulletin dealing with the design of modern industrial piping systems. Of particular interest is the method illustrated for determining the most economical pipe sizes and the amount of frictional resistance in straight pipe and bends.

Included in the bulletin are a number of charts by means of which correct pipe sizes and pressure drop can be easily figured. The charts are drawn up in such a manner that the most economical pipe size and amount of pressure drop can be read directly from the charts. The data covers the flow of fuel oils, lubricating oils, cotton seed oil, water, brine, gasoline and ammonia at temperatures ranging from —20°F. to 400°F.; and steam, air, oxygen, nitrogen, hydrogen and ammonia at temperatures from —100°F. to 1200°F.

K. Monel

INTERNATIONAL NICKEL CO., INC.

International Nickel Company, Inc., 67 Wall Street, New York, announces a new Monel metal called K. Monel, which combines strength of alloy steels with corrosion resistance of regular Monel metal. Four percent aluminum and fractional amounts of other elements are added to Regular Monel. It is readily heat treated to above 350 Brinell and tensile strength reported above 160,000 pounds per square inch.

Still Tube Cleaner

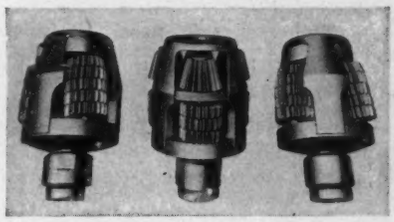
LIBERTY MANUFACTURING CO.

Liberty Manufacturing Company, Jeannette, Pa., announces improvements in still tube cleaner design and construction, tending toward a more rapid and thorough job of cleaning coke deposits from still tubes. Improvements include a new series of tube cleaner motors and cutting heads, a new type of lubricator, and a flexible joint. The cutting head is a combination type which can be assembled into three distinct heads, using different arrangements of cutters and giving varying angles of tilt to the cutters, making the heads suitable for various thicknesses and kinds of coke to be removed. The head is known as the Type U, is of the sliding, rotating pin type, and designed to feed into the coke automatically. The head spider

Liberty still cleaner, consisting of Type U cutter head, OB motor and tandem lubricator.

does not carry holes or slots for the pins. These are incorporated in replaceable plates.

The flexible drive joint gives a limited throw to the cutter head, giving the flexibility and extra swing necessary to clean sagged or warped tubes.



Showing the three head assemblies possible in the new Liberty Type U head.

The new Liberty tandem lubricator at the rear of the cleaner motor takes the place of the usual hose connection or reducer on the motor. It atomizes the oil and delivers lubrication directly into the motor, improving operation, and saving the hose.

The new Liberty "OB" motor delivers more power and speed with less air consumption. A heavier shaft increases durability and freer exhaust brings down back-pressure losses. The motor is made of highest grade alloy steel, especially heat treated.

Stair Tread

BLAW-KNOX COMPANY

Blaw-Knox Company, Pittsburgh, Pa., has announced that its stair tread now is manufactured using a nosing made from rolled diamond checkered plate. This nosing is made to withstand abuse, particularly that given to treads when buildings are under construction. It defines the edge of each tread because of the definite contrast between the checkered plate and the grating construction.

The stair tread is made from electroforged steel grating. The intersections of the bars are electroforged into one piece under enormous pressure. The twisted crossbar feature of the grating affords maximum safety as the roughened surface of the twisted bar affords a grip for shoe soles which makes slipping practically impossible.

Magnetic Starters

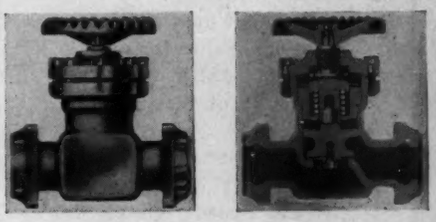
GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, N. Y., announces a new line of oil-immersed magnetic starters of the reduced-voltage, autotransformer type, in which all arcing contacts are six inches under oil. An induction-type temperature overload relay is used, also mounted in the oil. Either current-limit or time-limit acceleration is available, and an ammeter attachment can be supplied if desired. Ratings range upward to 600 amperes at 600 volts and 200 amperes at 2500 volts.

Diaphragm Packless Valves

KEROTEST MANUFACTURING CO.

Kerotest Manufacturing Company, Pittsburgh, Pennsylvania, is marketing a patented line of Diaphragm Packless Globe and Angle Valves said to have ideal advantages for handling propane, butane and the lighter hydrocarbon gases.



Kerotest Valves

The bolted, flanged bonnet construction and the short stem and metal diaphragm differs essentially from the packed valve in that the internal parts of the valve can be inspected or repaired in the full open position without removing the valve from the line and while the service line is under full pressure.

These valves are listed as standard by the Underwriters Laboratories and are made for ¼-inch to 1½-inch pipe sizes with pipe thread or four bolt hole, square flanges for secure installation.

Centrifugal Pumps

GARDNER-DENVER COMPANY

Gardner-Denver Company, Quincy, Illinois, is introducing a new line of centrifugal side-suction pumps. Developed after intensive study of user needs, these new pumps are designed especially for general service conditions in industrial work, as well as for intermittent service in other fields.

Higher efficiency with less power consumption, was one of the principal

No. 2BR 2½" to 4" inclusive

NEXT TIME SPECIFY

—a "TOLEDO" No. 2BR or No. 25BR.

No bushings. Held to the pipe by broad-faced chuck jaws with size-marked guide bars, operated by heavy set screws. Quick, easy, accurate centering.

No. 2BR uses a separate set of dies for each size. No. 25BR uses but one set of dies for all sizes.

Accurately built. Highest quality material used. Good for years of hard exacting service.

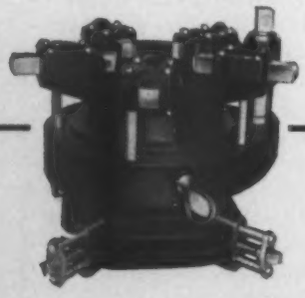
Remember better tools produce better work.

THE TOLEDO PIPE THREADING MACHINE CO. Toledo, Ohio

New York Office, 72 Lafayette St.

"TOLEDO"
THE TOOLS YOU NEED

No. 25BR 2½" to 6" inclusive



objectives in designing the Type B and C pumps, which handle capacities up to a half-million gallons per day, or 450 gallons per minute, at heads up to 100 feet.

Only a minimum of machining is done in the impellers, so that the hard outside skin, normal to cast iron, is preserved to give long life, particularly where abrasive materials are handled. Smoothness is obtained by a special foundry process.

Compactness and simplicity are also features of these pumps. The only moving parts in the pump are the shaft, impeller and bearing. A high grade, heavy-duty ball bearing at the pulley end of the shaft takes the thrust load and the belt pull, and, at the impeller end of the shaft, where the load of the bearing is light, an ample-size grease lubricated sleeve bearing is used. Water is piped to this bearing to lubricate it in case the attendant neglects to fill the grease cup.

Another feature of the new pumps is the thrust bearing, which is made adjustable to take up wear between the impeller and the casing. This adjustment of the thrust bearing is made by the use of shims, so that the bearing is positively held at all times.

The pumps are exceptionally sturdy. Frames, for example, are one-piece castings constructed of close grained cast iron accurately machined to fit the bearings and the volute, and are amply proportioned to resist belt pull and pressure in the pump. The shaft is made of best quality carbon steel.

Impact Wrench

INGERSOLL-RAND CO.

Ingersoll-Rand Company, Phillipsburgh, New Jersey, is marketing the Pott impact wrench which eliminates necessity of hammering caps and nuts in order to loosen them. S rubber member called an accumulator, is interposed between an air motor and a chuck. In operation torque from the motor is applied to the rubber accumulator which, in becoming shortened through twisting, lifts the hammer from engagement with the anvil. As soon as the hammer is released the untwisting of the rubber block spins the hammer forward to the next engagement, thus delivering a powerful twisting blow to the anvil, on the end of which the chuck is attached. These torsional impacts, occurring at the rate of 1200 to 1400 blows per minute, exert a powerful turning effect. One man operates the wrench with ease, the accumulator absorbing the torque and eliminating the danger of shock or injury to the operator.

Centrifugal Fire Pumps

WORTHINGTON PUMP & MACHINERY CORPORATION

Worthington Pump & Machinery Corporation, Harrison, N. J., has announced an improved line of Underwriter-approved, centrifugal fire pumps. These pumps are group LG, single-stage, volute type. Built particularly for fire protection service, their makers state that in every detail they are built for reliability in prompt starting and operation—both of vital consequence in all fire fighting apparatus. They are built for direct connection with electrical motors, Diesel, gas or gasoline engines, or steam turbines and, using the smallest approved size drivers in each instance, they occupy minimum location space.

These pumps are described as incorporating the modern features of centrifugal pump design, and are equipped with all fittings and accessories called for in every Underwriter specification. Each pump is fully inspected and approved for fire pump service by the National Board of Fire Underwriters and the Factory Mutual Fire Insurance Companies.

Electric Motor

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, has announced a new type of electric motor which utilizes a "stationary commutator" and has the characteristics of a series-type d-c machine but which operates from an a-c. power source. It was developed by E. F. W. Alexanderson, consulting engineer of the General Electric Company, Schenectady, New York. Known as a "Thyratron" motor, the new development is made possible by recent advances in the application of electron tubes. Announcement was made in a paper by Dr. Alexanderson and A. H. Mittag, also of the General Electric Company, which was discussed on January 24 at the A.I.E.E. winter convention in New York City.

One motor of this type, intended for use in driving an induced-draft fan, has already been built and is now on test in the Schenectady works of the company. It is rated 400 horsepower at 625 revolutions per minute and 75 horsepower at 350 revolutions per minute. These are the specified ranges of horsepower and speed for the particular application, although the motor may be successfully controlled down to standstill, if required. The equipment operates from a 2300-volt three-phase, 60-cycle power supply.

Among the noteworthy features of this motor are the following:

(1) While running from alternating current, the motor has the characteristics of a series-type direct-current machine.

(2) The speed of the motor is independent of the frequency of the power supply.

(3) Smooth control of the speed can be obtained over the full range.

(4) In event of a momentary interruption of the supply circuit, the motor will, upon the restoration of power, start and return to the speed at which it was previously operating, without drawing excessive current from the line.

(5) The efficiency is high and the efficiency curve relatively flat—a distinct advantage, particularly in the lower portion of the speed range.

Wrench

THE BILLINGS & SPENCER CO.

The Billings & Spencer Company, Hartford, Conn., has announced the "Gardnerench," a single jaw, double acting type for fittings, tong and pipe work. The manufacturer claims this wrench is the only type offering these advantages. The wrench is reversible without removing chain, is light in weight and well balanced, it is pointed out, and has a minimum crushing effect on pipe because chain and pipe are in the same plane.

Oil Remover

CURRAN CORPORATION

Curran Corporation, Somerville, Mass., has developed a new product for the removal of petroleum deposits from pipe lines, tank cars, machinery or floor surface. The new product has been named "Gunk," and is shipped in concentrated form. A full strength solution is secured by adding kerosene or light fuel oil. It is applied by spraying or brushing the product on the surface. The greases become water soluble and the accumulations are hosed off with cold water.

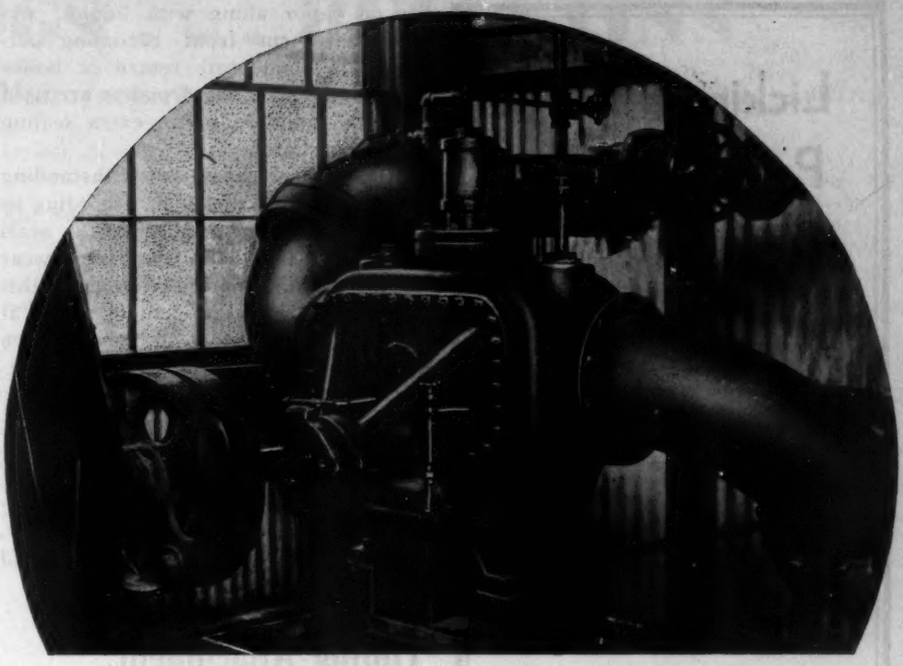
Condensate Units

ROOTS-CONNERSVILLE BLOWER CORPORATION

Roots-Connersville Blower Corporation, Connersville, Indiana, announces a new line of condensate units.

These units are intended for heating systems and boiler feed service, and are built in a comprehensive range of sizes, of from 2000 to 70,000 square feet of radiation.

The Type T pump incorporated in this design has an inherent high vacuum lift which enables these units to handle a considerable percentage of



Kinney Pumps for Asphalt

Using Kinneys for pumping asphalt and still bottoms comes as natural to refinery engineers as anything you can imagine.

They choose Kinneys for these services that most pumps shy at because experience has taught them that they are equal to the job.

Other Refinery Services, Too

But, for that matter, some one of the three types of Kinney Pumps is especially suited for your particular pumping job and Kinney Engineers will gladly advise which one if you will send full details to the office nearest you.

★ **KINNEY** ★

MANUFACTURING CO.

3539 WASHINGTON STREET, BOSTON, MASSACHUSETTS

NEW YORK: 30 Church Street — PHILADELPHIA: 725 Commercial Trust Building
CHICAGO: 1202 Buckingham Building — KANSAS CITY: 517 Finance Building
LOS ANGELES: 1333 Santa Fe Avenue

LIQUIDATING—ENTIRE ALTITUDE REFINERY

Located Chanute, Kansas, cost over a million dollars, operated until February, 1935. Will sell all or any item in plant consisting of 2—1000 bbl. ea. Jenkins cracking units, 5000 bbl. capacity skimming unit, 2000 bbl. Winkler-Koch pipe still, over 100 pumps all kinds, condenser boxes, heat exchangers, 150,000 bbl. steel storage, from 100 bbl. to 55,000 bbl., many miles of pipe lines, all sizes; 50,000 valves and fittings, laboratory equipment, complete stock of new repair parts. Inventories furnished on request.

Wire, Phone, Write—W. C. Berry or H. J. Galamba

SONKEN-GALAMBA CORPORATION, LIQUIDATORS
64-108 North Second Street — **Kansas City, Kansas**

Licking a Tough Paint-Stripping Job

Here the problem was to remove paint from the edges of dismantled oil storage tank plates in order to get a clean surface before welding.

First a caustic solution was applied. In twenty-five minutes it didn't even penetrate one of the four coats of paint. Then Oakite Cold-Strip, made up to the same proportions, was tried. It worked 100%. Every bit of paint was loosened and easily removed in the cold rinse.

If it's a question of cleaning or related operation, whether the job is unusual or an everyday task, you can profit, too, by the increased effectiveness of Oakite materials and methods. Write today for full details.

Manufactured only by

OAKITE PRODUCTS, INC.
50B Thames Street,
New York, N. Y.

Since 1909 the Standard of Cleaning Quality

OAKITE
Industrial Cleaning Materials and Methods

"Satisfactory" Satisfaction

Sand-Banum—"The Entirely Different Boiler Scale Eliminant"—is always sold on a "Satisfaction or No Money Guarantee." A guarantee on which we stake our entire reputation and prestige. There are no "ifs", no "buts" nor any "contingencies" attached to this guarantee—the efficiency of the product simply inspires unshakable confidence.

Sand-Banum definitely eliminates and prevents SCALE and CORROSION from boilers — it contains none of the usual "boiler chemicals" and **is absolutely harmless to all equipment.** It is the highest concentration known in boiler colloidal chemistry, therefore, it proves to be the most economical means of maintaining maximum boiler efficiency.

SAND BANUM

Send for Free Booklet—HOW and WHY.

American Sand-Banum Company, Inc.
342 Madison Ave., New York City
Stocks carried by
WESTERN SAND-BANUM COMPANY
Houston, Tex. Denver, Colo. Fresno, Cal.
and at other convenient points.

air or vapor along with liquids, and prevents them from becoming air-bound in condensate return or boiler feed service. Standard pumps are used with the addition of an extra sealing gland on shaft.

All seals are capable of withstanding temperatures up to 450°F., according to the manufacturers, and since the seals rotate with the shafts there is no wear on the packing material. Units of this type are designed to handle water at 190°F., but factory tests have shown that they function well at higher temperatures.

The manufacturers claim that these complete units make an ideal arrangement for handling both condensate return and make-up water, with the proper controls. Being fully automatic, these units are adapted to varying load conditions.

Timing Attachment

LANDIS MACHINE COMPANY

The Landis Machine Company, Waynesboro, Pa., recently placed on the market an attachment for use on its "Landmaco" threading machines for threading reduced body staybolts with a continuous thread on both ends.

The timing attachment consists of a bracket attached to the carriage end cover. This bracket is provided with positions for holding the gauge bracket as may be required for various lengths of staybolts. The gauge bracket arm attached to the gauge bracket carries the gauge for timing the thread. All plain radial staybolts are threaded with a 12-pitch thread and the gauge is made to fit. The gauge arm being pivoted in the gauge bracket permits it to be moved readily for clearing or engaging the thread.

Since a six-pitch leadscrew is used on the new threading machine and the staybolts are always threaded with a 12-pitch thread, the leadscrew nut on succeeding threads can be engaged at any point on the screw and provide a proper lead. After the original set up has been made a thread of continuous lead on both ends of the staybolt is assured.

The timing attachment gauge is made in the form of an insert held in the gauge arm. This permits making lateral adjustment of the gauge if desired. It also permits the use of various gauges of different thread forms and of different pitches at a minimum of cost.

Centrifugal Pump

WORTHINGTON PUMP & MACH. CORPORATION

Worthington Pump & Machinery Corporation, Harrison, New Jersey, announces development of an automatic self-priming Monobloc centrifugal pump for use in sumps, cellars, isolated water supply points and other industrial plant services.

The problem of priming has been solved through the use of the Worthington-built Hytor, which is a positive primer, placed on the same shaft with the motor and pump. The only requirement is a reasonably tight suction line. When the pump is primed, a pressure-operated cutout automatically unloads the Hytor. There is no recirculation of water. There are no floats. Nor are there valves to set or give trouble. The priming apparatus has been exhaustively tested for 10,000 starts, equivalent to more than 30 years of operation.

The unit is compact and neat, and is modern in appearance, with a sturdy splash-proof stream-lined motor, all on a symmetrical mounting. The pump is available for single or polyphase 50 or 60 cycle alternating current as well as for direct current operation.

REFINER AND NATURAL GASOLINE MANUFACTURER CIRCULATION

Average total distribution for six months ending December 31, 1934.

Mail Subscriptions—Individual	3661
Net Single Copy Sales	24
Mail Subs, Special (Par. 25)	231
TOTAL NET PAID exclud. Bulk	3916
Term Subscriptions in Bulk (Par. 26)	72
TOTAL NET PAID includ. Bulk	3988
Advertisers	159
Samples to Prospective Advertisers	231
All other unpaid distribution including correspondents, advertising agencies, exchanges, complimentary, subscription salesmen, samples and employees	614
Credit Subs. Canc. for Non-Payment	8
TOTAL DISTRIBUTION	5000

We hereby make oath and say that all statements set forth in this statement are true.

W. J. HUDSPETH, Circulation Mgr.
A. L. BURNS, General Manager.

Subscribed and sworn to before me this 22nd day of January, 1935.

J. KENT RIDLEY, Notary Public.
My commission expires June 1, 1935.

WANTED: Gas Measurement Engineer to train as field service engineer for manufacturer of general line of automatic controlling and recording instruments. Young single man, graduate of engineering school desired and highest character references required. Write stating age, education, experience and salary desired. Box 220, care Refiner and Natural Gasoline Manufacturer, Houston, Texas.

Electrically Driven Centrifuges
Hand Centrifuges
WRITE
WILLIAMS, BROWN & EARLE, Inc.
Manufacturers of Laboratory Apparatus
918 Chestnut St. Philadelphia, Pa.

CATALOGS . . . BULLETINS

Helpful Publications Which Manufacturers Will Be Glad to Send Free for the Asking

Baffles

Plibrico Jointless Firebrick Company, 1800 Kingsbury St., Chicago, has issued a new illustrated engineering bulletin dealing with Beco-Turner Baffles, which are now installed by this company.

Technical Bulletin

The International Nickel Company, 67 Wall Street, New York, is distributing Technical Bulletin TS-7 "The Resistance of Nickel and Monel Metal to Corrosion by Chlorinated Solvents Used in Dry Cleaning," which should prove of interest to users and manufacturers of metal products because of the growing use of chlorinated solutions in oil refining.

Instruments

The Brown Instrument Company, Philadelphia, is distributing an illustrated folder regarding reduction of steam costs in boiler room and plant processes. The folder calls attention to availability of the company's valuable Power Plant Instrument Data Book.

Recorders

The Hays Corporation, Michigan City, Indiana, is distributing Bulletin 2017 dealing with its new line of series "OT" and series "OH" draft, pressure and differential recorders for ranges between 0.1 inch water and 100 inches water, total scale.

Cooling Equipment

The Marley Company, Kansas City, Missouri, has issued a 48-page catalog illustrating "Marley Water Cooling Equipment," Request Bulletin 54. The catalog is profusely illustrated and shows application of Marley equipment to the cooling problems of a large number of industries.

Air Filters

Coppus Engineering Corporation, Worcester, Mass., has published two new bulletins dealing with air filters. Bulletin No. F-320-3 describes the Coppus unit type filter for motor and generator intakes and general commercial and industrial ventilation. Bulletin No. F-310-2 contains complete data on filters for air compressors, internal combustion engines, etc. Sizes, shapes and capacities of filters are given in tabular form.

Acid Treating

Stratford Engineering Corporation, 1414 Dierks Building, Kansas City, Mo., has prepared Bulletin 200 "Stratford Contactor-Centrifuge Acid Treating Process," an engineering and technical discussion of the process, well illustrated with photographs and flow diagrams.

Equipment

Shand & Jurs Company, Berkeley, Calif., has issued a 32-page catalog dealing with "Storage Tank Equipment," including engineering information, photographs and diagrams of equipment and its application.

Control

C. J. Tagliabue Manufacturing Company, Park and Nostrand Avenues, Brooklyn, is distributing a new pamphlet dealing with photoelectrically balanced indicating potentiometer controllers.

Valves

Parker Appliance Company, Cleveland, Ohio, has issued Bulletin No. 38, a price list and catalog of Parker valves. The 56-page booklet is well illustrated and includes all pertinent engineering information.

Air Nozzles

The Lunkenehimer Company, Cincinnati, Ohio, is distributing a new bulletin dealing with its improved air nozzles with renewable nonmetallic disc.

Pumps

Worthington Pump & Machinery Corporation, Harrison, N. J., has prepared for distribution the following bulletins: Monobloc Centrifugal Pump; Three-Stage Volute Type U. C. Centrifugal Pumps; Centrifugal Pumps, type C, CA and CB; Centrifugal Fire Pumps; Single Stage Volute Type LG, and Monobloc Centrifugal Pumps, Type DE, DF and DG.

Circuit Breakers

General Electric Company, Schenectady, New York, has prepared Bulletin GEA-1662A, dealing with its trip-free, air circuit breakers for buildings, industrials and power stations, including all pertinent engineering information.

Valves

The Lunkenheimer Company, Cincinnati, Ohio, has prepared a new bulletin dealing with its "Causul" metal gate valves for corrosive service, with ML-3 alloy trim and A-7-S alloy trim.

Refractories

The General Refractories Company, 106 South 16th Street, Philadelphia, has an interesting and valuable series of booklets on the company and its products. No. 101 deals with refractory products and service; No. 201, fire clay brick refractories; No. 202, high grade refractories from the South; No. 203, plastic fire brick; No. 204, chrome base high temperature cement; No. 205, fire clay and cyanite base high temperature cements; No. 301, refractories for metallurgical processes; No. 302, refractories for rock products industries; No. 303, refractories for boiler plants, and No. 304, refractories for oil refineries.

Ejectors

Elliott Company, Pittsburgh, Pa., announces through its Heat Transfer Department at Jeannette, Pa., a new publication on steam jet ejectors. The bulletin goes into the theory and operating principle of steam jet ejectors, decribes single- and multi-stage ejectors, boosters, materials of construction, facts on operating and application to numerous processes.

Equipment

General Electric Company, Schenectady, N. Y., has issued the following bulletins: Turbines for Mechanical drive, single stage steam turbines, 40 to 400 hp; and Turbines for Mechanical Drive, multi-stage steam turbines, 100 to 200 hp., type D-60 and type DS-60; A bulletin on Metal Enclosed Switchgear; a bulletin on General Electric Arc Welders, and one on G.E. welding electrodes and accessories.

Belts

The B. F. Goodrich Company, Okron, Ohio, has issued a folder which tells of the strides made in the manufacture of rubber belts. The folder describes the 14 ways in which the latest type Goodrich belt has been improved.

Power Drills

Chicago Pneumatic Tool Company, New York City, has ready for distribution Bulletin No. SP-1876, which describes the company's "Power Vane" rotary drills.

Compressors

Sullivan Machinery Company, Chicago, has issued a 32-page catalog describing its new line of "Plus Portable" two-stage air cooled compressors in four sizes, 105 cubic foot, 160 cubic foot, 210 cubic foot, and 315 cubic foot, available in all desired mountings.

Control

Bailey Meter Company, 1050 Ivanhoe Road, Cleveland, Ohio, is distributing Bulletin 83, 16 pages describing this company's thermo-hydraulic, automatic feed water regulators.

Electrical Equipment

General Electric Company, Schenectady, N. Y., is distributing the following publications: GEA-612B—56 pages on demand meters; GEA 897E—19 pages on air cooled transformers; GEA-1305C—34 pages on luminous tube transformers; GEA-1662E—dealing with trip-free air circuit breakers.

Classifier

The Hardinge Company, York, Pa., is distributing a pamphlet on its small commercial or laboratory classifier of the rotary type.

Boilers

Union Iron Works, Erie, Pa., announce publication of a new bulletin on Union Radiant Heat Boilers, of interest and value to those who operate boiler plants.

USE THIS COUPON
(Address manufacturer direct)

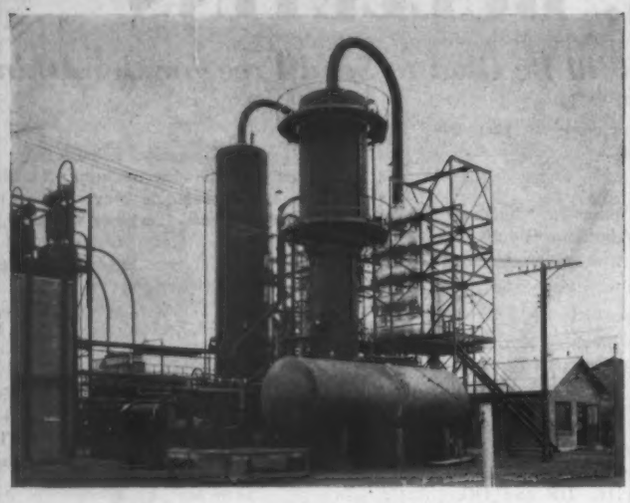
. . . . . .

. . . . . .

Please send me, without obligation, free booklet described in May, 1935, issue of REFINER AND NATURAL GASOLINE MANUFACTURER.

NAME . . . . . .

ADDRESS . . . . . .



2-Stage Cracked Gasoline Re-Run Still

You should have copies of our new "Petroleum Distillation Equipment Bulletin" and "Condensed General Catalog" in your files. If you have not received copies, write for them today.

Send us your inquiries

J. P. DEVINE MFG. CO., Inc.

Subsidiary of Mt. Vernon Car Mfg. Co.
MOUNT VERNON, ILL.

BROWN-STRAUSS CORPORATION

Offers

For sale and prompt delivery the entire plant and equipment of

THE CONTINENTAL OIL REFINERY AT SAPULPA, OKLAHOMA

Now being dismantled

In many years' experience dismantling and selling refinery equipment we have never had the opportunity of offering such late-type, high-quality, well preserved machinery, etc. This Refinery was operating up to 1933, and is in such good repair and preservation as to be practically in operating order now. It is far from the usual abandoned, obsolescent type of plant commonly offered under this heading. Modern hot-oil pumps, instruments, boiler plant tanks—in fact the entire equipment of this two million dollar topping and cracking plant at bargain prices for quick sale. Tremendous quantities of all sizes of pipe, cast steel valves and fittings.

Write for Circular. Salesmen on Premises.

BROWN-STRAUSS CORPORATION

Mail address, P. O. BOX 220 SAPULPA, OKLAHOMA

Main Office and Plant
KANSAS CITY, MISSOURI

Advertisers' Index

Alco Products, Inc. 25a
American Brass Company 23a
American Meter Company 19a
American Sand-Banum Company 56a
Armstrong Machine Works 22a

The Bristol Company 24a
The Brown Instrument Company 15a
Brown-Strauss Corporation 58a

The Chaplin-Fulton Manufacturing Company 50a
Chemical Construction Corporation 21a
Chicago Bridge & Iron Works 44a
Cooper-Bessemer Corporation 30a
Crescent Tool Company 31a

DeLaval Steam Turbine Company .....Third Cover
J. P. Devine Manufacturing Company 58a

The Eagle-Picher Lead Company 27a
Elliott Company 4a

Fish Governor Company 35a
Fluor Corporation 20a
Foster Wheeler Corporation 29a
The Foxboro Company 13a
The Frick Company 51a

Gasoline Products Company 43a
General Electric Company 7a
Goulds Pumps, Inc. 18a

Haden Lime Company 35a
Hanlon-Buchanan, Inc. .....Front Cover

International Nickel Company 12a

Jerguson Gage & Valve Company 28a
Johns-Manville Corporation 45a
The Johnston & Jennings Company (Oceco Division) 39a

The M. W. Kellogg Company .....14a and 49a
Kieley & Mueller, Inc. 50a
Kinney Manufacturing Company 55a

The Labour Company 51a
The Lagonda Manufacturing Company 48a
Lincoln Electric Company 8a
The Lummus Company 26a
Lunkenheimer Company 46a

Mason-Neilan Regulator Company 5a
Merco Nordstrom Valve Company 11a
The Midvale Company 16a
Mines Safety Appliances Company 28a

National Tube Company 32a
W. H. Nicholson & Company 52a

Oakite Products, Inc. 56a

Pittsburgh Steel Company 6a

Quimby Pump Company 38a

Reading Iron Company 51a
Republic Steel Corporation .....37a and Back Cover
The Ridge Tool Company 24a
The Roto Company 38a

Sarco Company 52a
Sonken-Galamba Corporation 55a
Sun Shipbuilding & Dry Dock Company 10a

C. J. Tagliabue Manufacturing Company 17a
Taylor Instrument Companies 9a
The Toledo Pipe Threading Machine Company .. 54a

Universal Oil Products Company 47a

Henry Vogt Machine Company .....Second Cover

Westco Pumps Corporation 41a
J. H. Williams & Co. 40a
Williams, Brown & Earle, Inc. 56a